CHAPTER 3 PV RURAL ELECTRIFICATION PLAN

3.1 Identification of PV Market and Potential Demand

(1) Market Characteristics of SHS

As a type of electricity supply, PV is classified into solar power station, hybrid solar power station, and a family photovoltaic system (solar home system, SHS). The types of solar power and hybrid system consisting of generators and distribution line are defined as the closed network whose service coverage is restricted, supplying one or two villages. Such a closed network can be connected to grids of SENELEC or other networks. SHS is, on the other hand, an independent unit, easily installed at users' dwelling properties. SHS does not require a collective demand as a project of LV distribution needs.

Rural electrification in developing countries is generally characterized by low electricity consumption of end-users concentrating on the middle to high income classes dwelling in villages or isolated areas. Electricity use is largely restricted to lighting, say, five (5) to ten (10) kWh per month. Lighting is implicitly regarded as the basic electricity use in SHS-based rural electrification.

The market characteristics of SHS are summarized as follows:

a) End-users are presumed to be extensively diffused in villages scattered nationwide. Such an individual demand might be identified in villages having smaller middle scale of population.

b) End-users are those who can afford to purchase a fairly expensive unit or to pay the constant service fee periodically. They are thus presumed to belong to the middle to high income classes.

c) The economic nitch for SHS usually covers remote or isolated areas where load or load density is low. The market nitch for SHS is to be determined by size of household demand for electrification and the distance from existing grid.

(2) Basic Conditions

A demand for SHS is defined as a household being willing to install a SHS unit. The market study is to identify spatial distribution of villages having potential demand for SHS and to make the quantitative analysis of such demand by locality or region. Potential demand for SHS is to be estimated with the following conditions:

a) The market segmentation complies with twenty (20) concession areas proposed in "Procedure Manual" of ASER.

b) There are the different types of SHS according to power output. This study primarily focuses on the standard type of 50 wp to be presumed to be extensively diffused in all Senegal.

c) The basic data such as population and family size at present (the year of 2000) is estimated based on those of the previous census year (1988) owing to no successive census data.

d) The target year of demand forecast is that of 2015 in accordance with PASER.

(3) Methodology

The identification of SHS market starts with potential demand for electrification at the level of village. Potential connection rates by size of village population is hypothesized in the Procedure Manual. These hypothetical connection rates are used to estimate potential demand for electrification for all the non-electrified villages.

Next, the costs per kWh are compared among three technical options (grid extension, diesel generator, and SHS) in order to find out cost effective area for SHS in relation to the distance from existing grid and household demand for electrification. The more household demand is, the less electrification cost is. The cost per kWh diminishes as household demand becomes larger.

Finally, the market study ends up with identification of villages where SHS is to be introduced and potential demand for SHS by concession area. The methodology for SHS market analysis is conceptually illustrated in Figure 3.1.

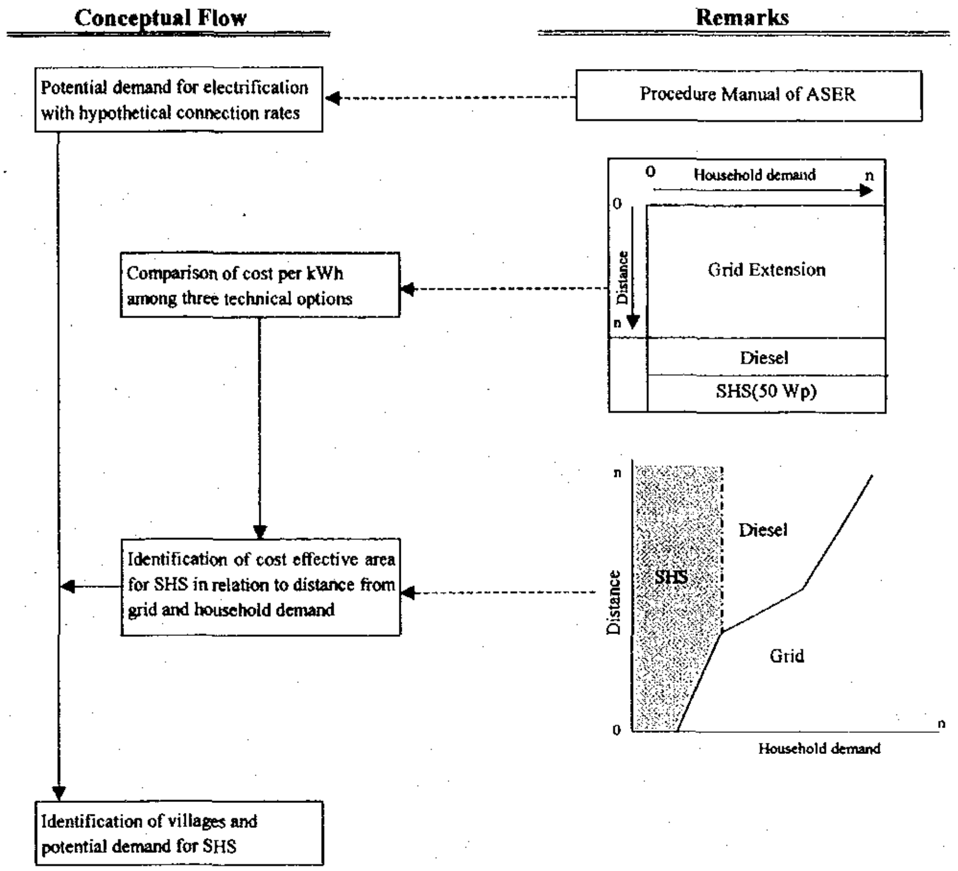


Figure 3.1 Conceptual Flow for Estimation of Potential Demand for SHS

Estimation of potential demand for electrification at present is simple, referring to the village population of the year 2000 (estimate) and hypothetical connection rates quoted from Procedure Manual. Electrification cost of grid extension takes the form of matrix with respect to household demand and distance from grid. Extension cost increases in proportion to distance from grid, whereas that diminishes as demand grows. Electrification cost of diesel diminishes as demand grows, while that of SHS seems to be constant in little relation to size of demand. The shaded area corresponds to cost effective area for SHS, resulted from comparison of cost per kWh among three technical options. Finally, the number of village including demand for SHS in SHS area is to be estimated by concession area.

(4) Potential Demand for Electrification

Village data on population and distance from grid is available for about 11,571 villages. Village population in the year of 2000 is estimated based on the previous census data in

1988. Connection rates by size of population is quoted from the Procedure Manual and shown below.

(P: Village population) (unit: %)

	P > 1,000	500 < P ≤ 1,000	250 < P ≤ 500	P ≤ 250
Connection rates	40	30	20	10

Source: Procedure Manual

The SHS demand of the household by village population aggregate was estimated as shown on Table 3.1.

Table 3.1 SHS Demand by Village Population Aggregate

(P: Village population)

	P > 1,000	500 < P ≤ 1,000	250 < P ≤ 500	P ≤ 250	Total
Nos. of villages	712	1,603	2,742	6,514	11,571
Potential demand	54,174	35,559	20,699	8,318	118,750

(5) Cost Comparison

The unit costs (cost per kWh) of the three technical options are compared for identification of cost effective area of SHS in relation to distance from grid and household demands. A kWh cost is expressed by the following equation.

$$U = \frac{\Sigma Ac}{E}$$

where U = Unit cost
ΣAc = Aggregation of annualized cost of components
E = Yearly energy consumption (mainly for lighting) of a rural household

Assuming that 50Wp is the main type of SHS to be diffused in rural area, the yearly energy consumption per household is estimated as follows.

$E = 50w \times 4hrs \times 365\ days = 73kWh$

Where 4hrs: hours of daily use per household

The energy consumption of 73kWh is a common denominator to calculate respective kWh cost of three (3) technical options. The formula of annualized cost (Ac) is given by the following equation.

Ac=Cc×CRF where Cc=Component Cost

CRF= Capital recovery factor given a discount rate of 12%

A component indicates a part of a technical option (i.e. MT line, LV line of grid extension). Annualized cost by component is aggregated to estimate annualized cost by technical option. The result of kWh cost comparison is shown in Table 3.2 and briefly explained below.

The kWh cost of SHS (a 50wp) is constant regardless of a variation of demand and estimated to be 1,160FCFA. On the other hand, kWh cost of grid extension and diesel diminishes as the demand grows.

Table 3.2 Cost Per kWh of SHS Grid and Diesel with Respect to Distance and Demand

(Unit: FCFA)

Distance	Household Demand											
	5	10	15	20	25	30	42	70	105	140	210	308
0km	3,387	2,027	1,574	1,347	1,211	1,120	991	861	796	764	736	714
1 km	8,396	4,531	3,243	2,599	2,213	1,955	1,587	1,219	1,035	943	855	795
2 km	13,405	7,036	4,913	3,851	3,215	2,790	2,183	1,577	1,273	1,122	975	877
3 km	18,414	9,541	6,583	5,104	4,216	3,625	2,780	1,935	1,512	1,301	1,094	958
4 km	23,424	12,045	8,252	6,356	5,218	4,460	3,376	2,292	1,751	1,480	1,213	1,039
5 km	28,433	14,550	9,922	7,608	6,220	5,295	3,972	2,650	1,989	1,658	1,332	1,121
6 km	33,442	17,054	11,592	8,861	7,222	6,129	4,569	3,008	2,228	1,837	1,452	1,202
7 km	38,451	19,559	13,262	10,113	8,224	6,964	5,165	3,366	2,466	2,016	1,571	1,283
8 km	43,460	22,064	14,931	11,365	9,226	7,799	5,761	3,724	2,705	2,195	1,690	1,365
9 km	48,469	24,568	16,601	12,618	10,227	8,634	6,358	4,081	2,943	2,374	1,809	1,446
10 km	53,479	27,073	18,271	13,870	11,229	9,469	6,954	4,439	3,182	2,553	1,929	1,527
15 km	78,525	39,596	26,619	20,131	16,238	13,643	9,936	6,228	4,374	3,447	2,525	1,934
20 km	103,570	52,119	34,968	26,393	21,248	17,817	12,917	8,017	5,567	4,342	3,121	2,340
25 km	128,616	64,642	43,317	32,654	26,257	21,992	15,899	9,806	6,760	5,236	3,718	2,747
SHS(50W)	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160	1,160
Diesel	6,286	3,459	2,517	2,045	1,763	1,574	1,305	1,092	994	998	945	908

Remarks: The estimation of cost per kWh is based on annual electricity consumption (73kWh) of a family.

SHS has the comparative advantage against grid irrespective of distance in case demand(D) ranges from zero(0) to thirty(30), $0<D<30$. As the demand grows, a breakeven point of grid and SHS gradually shifts from zero(0) in terms of distance, which is shown in Figure 3.2.

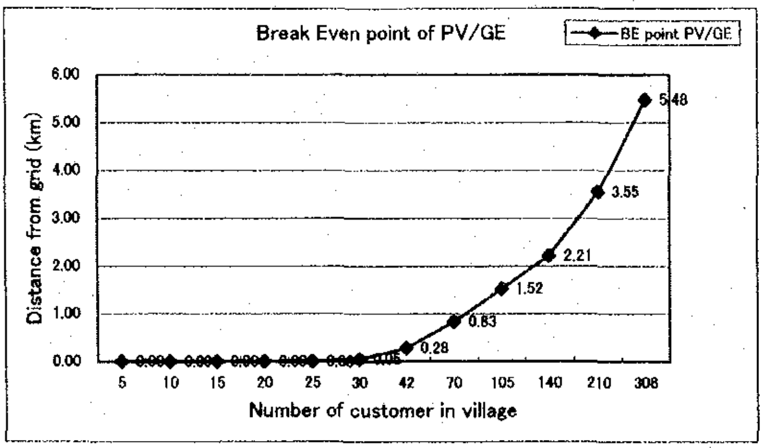


Figure 3.2 Break Even Point of PV/GE

The distance indicating a breakeven point increase from 0.05km of D=30 to 5.48km of D=308. The cost per kWh of diesel diminishes as the demand grows, and is equivalent to that (FCFA 1,160) of SHS at 60 household demands. The comparison of the kWh cost of diesel to that of SHS is shown in Figure 3.3

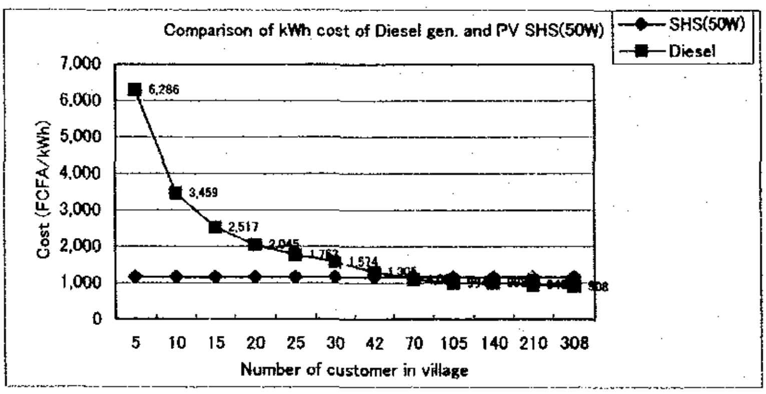
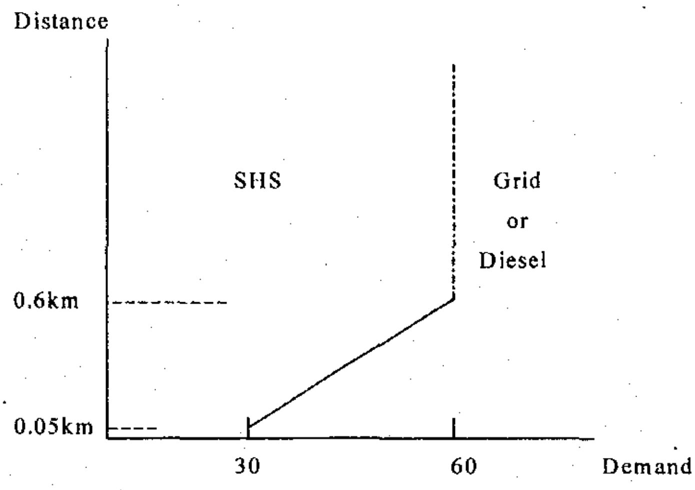


Figure 3.3 Comparison of kWh Cost of Diesel Gen and PV SHS (50W)

In short, the demand (60) is a breakeven point of diesel and SHS. Given the demand of 60, the distance indicating a breakeven point of grid and SHS in Figure 3.2 is estimated to be about 0.6km. The cost comparison discussed so far is briefly illustrated below.



The breakeven points of diesel and grid is shown in Figure 3.4. The distance indicating the breakeven points appears to be constant around 0.55km between zero (0) and seventy (70) in terms of demand. Then the distance gradually increases from 0.53km of D=70 to 2.38km of D=308. The breakeven points of diesel and grid are inserted into the previous graph to present cost effective areas for SHS, diesel and grid, as shown in Figure 3.5.

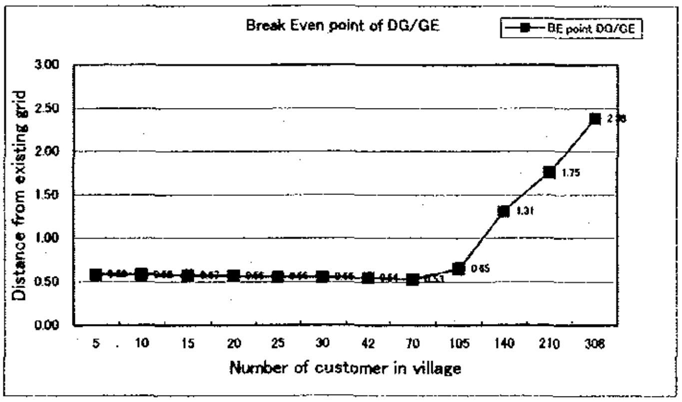


Figure 3.4 Breakeven Point of DG/GE

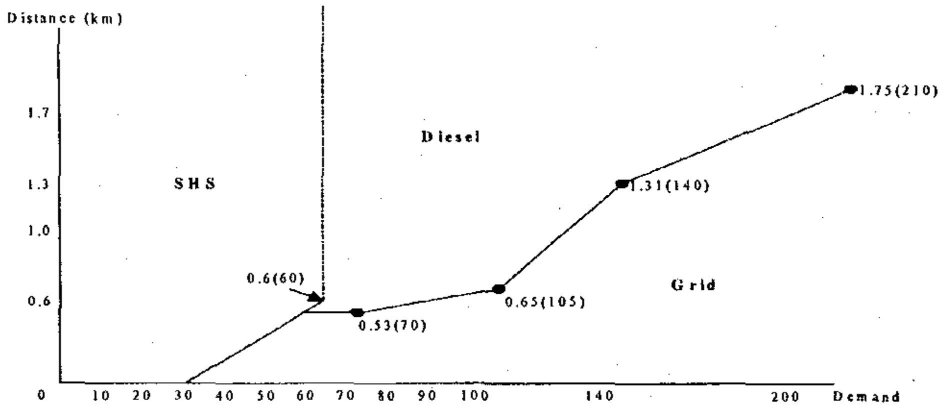


Figure 3.5 Cost Effective Area for SHS, Diesel and Grid

(6) Village Distribution of SHS Area

The cost effective area for SHS, indicating the number of villages is shown in Figure 3.6 and summarized as follows:

a) The number of non-electrified villages in SHS area turns out to be 11,222. The majority of non-electrified villages is thus identified to be those for SHS-based rural electrification.

b) Out of 11,222 villages, the majority of them is identified in SHS area where the distance is over 0.6km, and demand is in the range from 1 to 30 households. The number of villages in this block is estimated to be 6,695.

c) The second largest block of village distribution is the area where the distance is more than 0.6km and demand in the range from 30 to 60. The number of villages in the second block is estimated to be 4,004.

d) The number of villages in the third and fourth blocks is estimated to be 299 and 224, respectively.

(7) Present Demand for SHS

The regional distribution of potential demand is illustrated by histograms as shown in Figure 3.7 and summarized in Table 3.3.

Table 3.3 Regional Distribution of Potential Demand

Region	Demand	Region	Demand
Dakar	115	Louga	7,243
Diourbel	9,364	Saint louis	7,247
Fatick	9,235	Tambacounda	7,640
Kaolack	14,321	Thies	12,130
Kolda	10,240	Ziguinchor	4,998
		Grand total	82,533

Potential demand is estimated to be 82,573 in all regions. The market has a big potential demand for SHS at present. Kaolack is the top region, accounting for 14,321 units while Ziguinchor demands the least units (4,998), except for non-electrified commune area of Pakar.

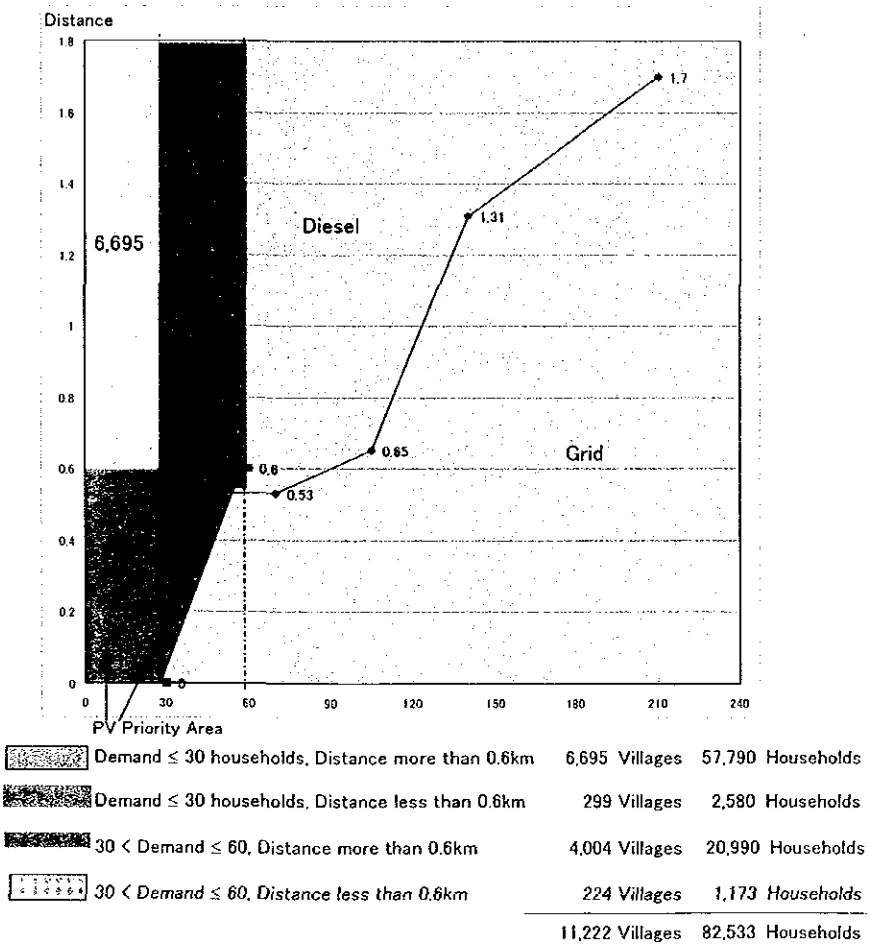


Figure 3.6 Distribution of Villages in SHS Area

Table 3.3 Regional Distribution of Potential Demand

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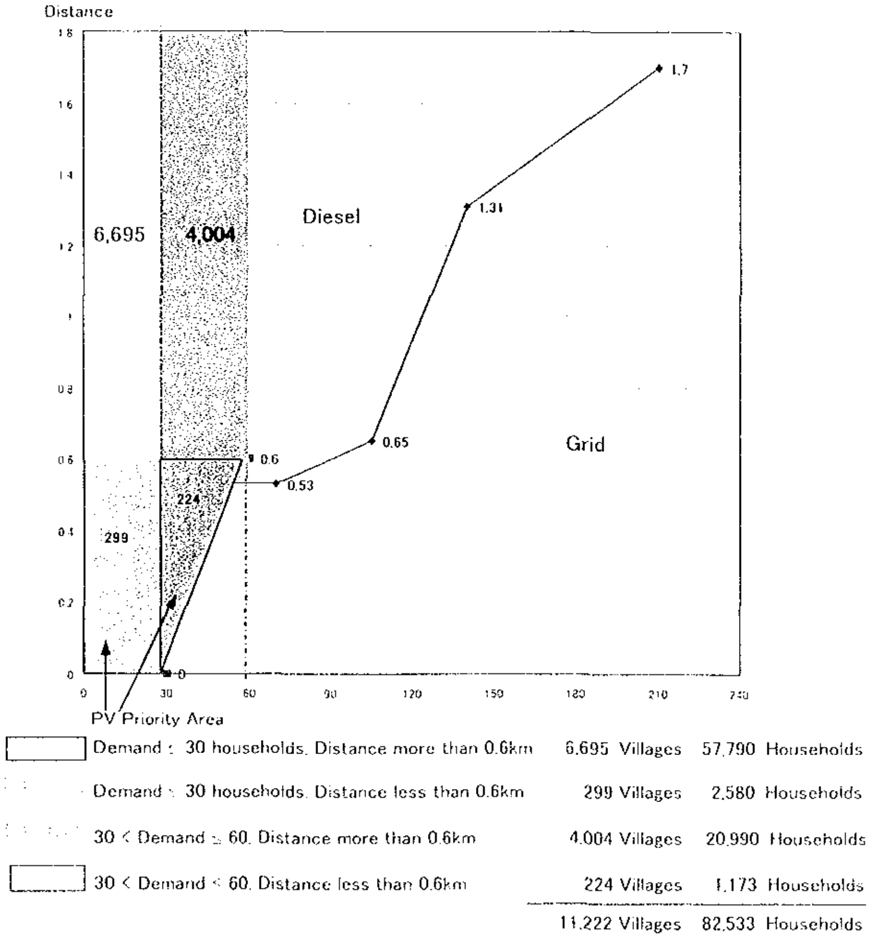


Figure 3.6 Distribution of Villages in SHS Area

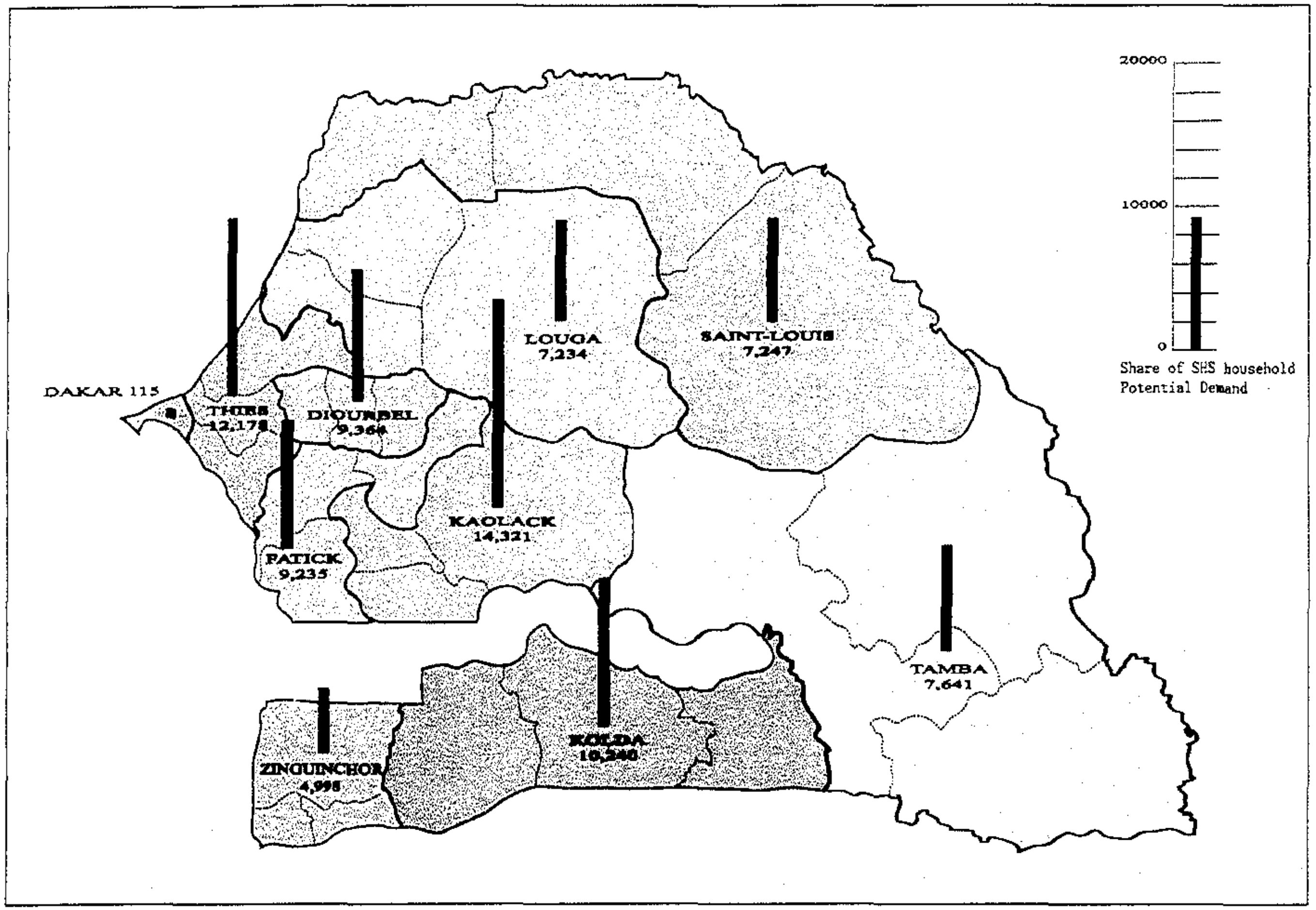


Figure 3.7 Regional Distribution of Potential Demand for SHS

Potential demand for SHS is disaggregated into department including the number of community rural (CR) and villages, as shown in Table 3.4.

Table 3.4 Potential Demand for SHS by Department

Region	Dept	Nos of CRs	Village	Demand
Dakar	Rufisque	1	10	115
Diourbel	Bambay	13	401	4,435
	Diourbel	11	340	2,792
	Mbacke	11	282	2,137
Fatick	Fatick	14	185	3,044
	Foundiougne	9	307	3,097
	Gossas	12	282	3,094
Kaolack	Kaffrine	21	847	7,313
	Kaolack	9	429	3,168
	Nioro du Rip	11	456	3,840
Kolda	Kolda	13	677	2,748
	Sedhiou	20	573	5,536
	Velingara	10	422	1,956
Louga	Kebemer	16	796	1,957
	Linguere	17	664	2,924
	Louga	15	776	2,362
Saint Louis	Dagana	6	261	2,100
	Matam	12	254	3,128
	Podor	10	148	2,019
Tamba	Bakel	10	400	2,102
	Kedougou	10	221	1,746
	Tamba	13	737	3,792
Thies	Mbour	8	123	2,844
	Thies	9	348	4,103
	Tivaouane	15	859	5,183
Ziguinchor	Bignona	15	279	3,094
	Oussouye	4	68	1,002
	Ziguinchor	5	74	902
	Total	320	11,219	82,533

Twenty (18) concession areas are proposed in the "Procedure Manual" of ASER. potential demand is again disaggregated by concession area, as shown in Table 3.5. Potential demand for SHS by concession area is illustrated in Figure 3.8.

Table 3.5 Potential Demand for SHS by Concession Area

Number	Concession	Nos of CR	Villages	Demand
1	Ziguinchor	24	421	4,998
2	Diourbel-Bambay	24	741	7,227
3	Mbacke	11	282	2,137
4	Dagana-Podor	16	409	4,119
5	Matam	12	254	3,128
6	Tambacounda-Kedougou	23	958	5,538
7	Bakel	10	400	2,102
8	Kaolack-Nioro du Rip	20	885	7,008
9	Kaffrine	21	847	7,313
10	Tivaouane	15	859	5,183
11	Thies	9	348	4,103
12	Mbour	8	123	2,844
13	Kebemer-louga	31	1,572	4,319
14	Linguere	17	664	2,924
15	Gossas-Fatick	26	467	6,138
16	Foundiougne	9	307	3,097
17	Sedhiou	20	573	5,536
18	Kolda-velingara	23	1,099	4,704
	Total	319	11,209	82,418

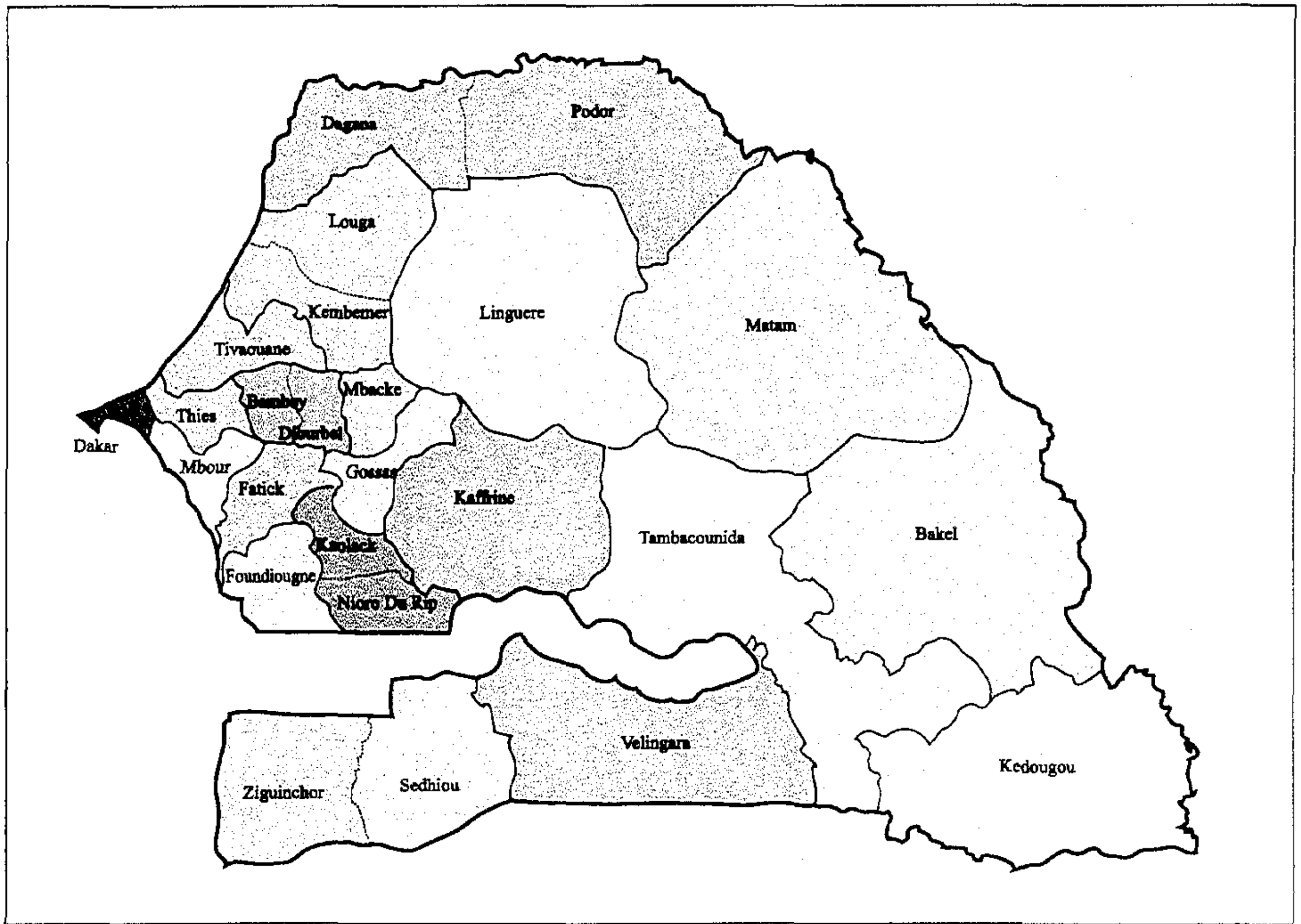


Figure 3.8 Potential Demand for SHS by Concession Area

(8) Demand Projection

1) Assumptions

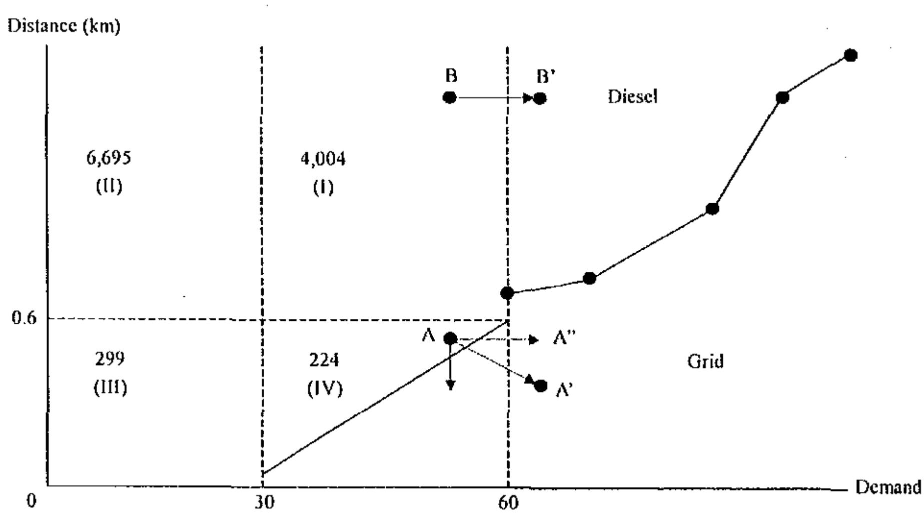
First of all, two (2) assumptions have to be made clear prior to demand projection.

Cost effective area for SHS

Electrification costs of three technical options and annual electricity consumption (73 kWh) per rural consumer are assumed to be the same in 2015. Accordingly, the cost effective area for SHS shown in Figure 3.6 can be utilized for demand forecast of 2015 as well.

SHS villages in transitory area

Villages in SHS area identified in relation to household demand and distance from the existing grids might shift to grid or diesel areas due to the future extension of SENELEC grids or increase of village population.



Two villages marked by A and B are examples which are to shift to A' (grid) and B' (diesel) respectively. The village of A currently locating within 0.6 km from existing grid might shift in the direction of the downward arrow due to the future extension of SENELEC grid, while the shift indicated by the arrow (→) of the right-hand direction is attributed to population increase.

A combined effect of grid extension and socioeconomic development would result in the shift from A to A'. Nevertheless, the future extension of SENELEC grid is unknown and SENELEC might take interest in villages having demands more than 60. Thus the downward shift of A is assumed to be unlikely in the future. Though A shifts to A', A will be unlikely to be connected to the future extension of SENELEC grid because their interest of RE is principally directed to urban area and rural area with high potential demand. Thus villages including A in the block of (IV) will continue to be the SHS area in the future.

The effect of socio economic development on the village B would result in the shift from B to B' (diesel area). A careful attention should be paid to villages locating in transitory area, those having the current demand between 50 and 60 in the block of (I). A double investment on SHS first and diesel secondly would bring a financial burden to a concession-holder. SHS units installed first would be used as the second-hand after a diesel takes over SHS units. But the second-hand market of SHS units would gradually develop, following the spatial diffusion of the brand new market. The most important thing will be the needs of rural consumers regarding choice of RE modes. In this Study, villages whose demands are either now 60 or to reach 60 at the launching stage (2001-05) are excluded from SHS area.

Most villages concentrating in the blocks of (II) and (III) will generate the entry of new subscribers to the SHS market due mainly to socioeconomic development. New subscribers are to be estimated based on forecast of demography growth by department.

In conclusion, the entry of new subscribers to the market is assumed to generate in SHS villages identified in Figure 3.6, except for some villages in the block of (I) to be taken over by a mode of diesel generator sooner or later.

2) Average annual growth rate of village households ·

An estimation of the future demography is based on "Population du Senegal DPS" in which population is estimated by department for the period of 1990 to 2015. The growth rate of the national population estimated by DPS is quite close to that estimated by "World Population projection, 94/95" of the World Bank. Growth rates of village households are the same as those of population provided that family sizes of the census year (1988) are assumed to remain unchanged 1990 through 2015. Thus average annual growth rates of village households by department can be estimated based on the projected population of both 2000 and 2015, which is shown in Table 3.6.

Table 3.6 Average Annual Growth Rates of Population by Department (2000-2015)

Region	Department	Rate (%)
Dakar	Rufisque	3.03
Ziguinchor	Bignona	0.48
	Oussouye	1.74
	Ziguinchor	1.26
Diourbel	Bambay	1.33
	Diourbel	0.33
	Mbacke	4.20
Saint Louis	Dagana	1.11
	Matam	1.95
	Podor	-0.99
Tamba	Bakel	1.86
	Kedougou	-1.84
	Tamba	2.72
Kaolack	Kaffrine	1.97
	Kaolack	1.45
	Nioro	2.29

Region	Department	Rate (%)
Thies	Mbour	1.94
	Thies	2.14
	Tivaouane	1.30
Louga	Kebemer	-4.13
	Linguere	2.63
	Louga	-3.83
Fatick	Fatick	0.29
	Foundiougne	2.06
	Gossas	0.88
Kolda	Kolda	2.06
	Sedhiou	1.96
	Velingara	1.82

3) SHS villages in transitory area

It is already explained that some villages in the block of (I) in Figure 3.6 have to be excluded from SHS market area. Villages excluded are those whose demands are now 60 and will reach to 60 at the launching stage. The method of identifying villages in transitory area is given below:

Demand for SHS in Kolda	2000		2005
Village household	54		60

How SHS villages in transitory area can be estimated, is shown by the case of the department Kolda. A village generating 60 demands in 2005 is supposed to have 54 demands in 2000 in the following equation:

$$A \times (1 + 0.0206)^5 = 60 \qquad A = 54,$$

where 2.06% represents average annual growth rate of population in Kolda.

A village having SHS demands of more than 54 is potentially regarded as those to be electrified by diesel generators. SHS villages in transitory area in terms of the current demand are estimated in Table 3.7.

Table 3.7 Current Demands of Villages in Transitory Area

Region	Department	Demand	Region	Department	Demand
Dakar	Rufisque	51	Thies	Mbour	54
Ziguinchor	Bignona	58		Thies	54
	Oussouye	55		Tivaouane	56
	Ziguinchor	56	Louga	Kebemer	74
Diourbel	Bombay	56		Linguere	53
	Diourbel	59		Louga	73
	Mbacke	49	Fatick	Fatick	59
Saint Louis	Dagana	57		Foundiougne	54
	Motam	54		Gossas	57
	Podor	63	Kolda	Kolda	54
Tamba	Bakel	55		Sedhiou	54
	Kedougou	66		Velingara	55
	Tamba	52			
Kaolack	Kaffrine	54			
	Kaolack	56			
	Nioro	53			

SHS villages in transitory area are summarized in Table 3.8.

Table 3.8 SHS Villages in Transitory Area

Region	Department	Nos. of villages	Demand	Region	Department	Nos. of villages	Demand
Dakar	Rufisque	0	0	Thies	Mbour	5	278
Ziguincho	Bignona	1	58		Thies	8	459
	Oussouye	2	117		Tivaouane	3	171
	Ziguinchor	2	117	Louga	Kebemer	0	0
Diourbel	Bambay	2	115		Linguere	3	171
	Diourbel	0	0		Louga	0	0
	Mbacke	6	317	Fatick	Fatick	1	59
Saint Lou	Dagana	0	0		Foundiougne	6	346
	Matam	8	447		Gossas	0	0
	Podor	0	0	Kolda	Kolda	2	113
Tamba	Bakel	4	233		Sedhiou	7	398
	Kedougou	2	104		Velingara	0	0
	Tamba	6	335	Total		84	4,753
Kaolack	Kaffrine	8	456				
	Kaolack	3	173				
	Nioro	5	286				

4) Demand Projection

SHS demands towards the target year of 2015 are estimated by market area, as shown in Table 3.9. The demands of SHS villages in transitory area are excluded from a demand projection. SHS demands are estimated as follows:

$$D_i^n = D_i^{2000} \times (1 + Gr)^n$$

where D_i^n = potential demand for SHS in the n[th] year by concession area (i)

$1 \leq i \leq 20$

G_r = average annual growth rate of population by department (r)

$1 \leq r \leq 28$

D_i^{2000} = potential demand for SHS in 2000 by concession area (i)

Table 3.9 Demand Projection

Number	Concession Area	2000	2005	2010	2015
1	Zinguinchor	4,706	4,911	5,459	5,355
2	Diourbel-Bambay	7,112	7,576	7,947	8,340
3	Mbacke	1,820	2,625	3,225	3,961
4	Dagana-Podor	4,119	4,140	4,173	4,217
5	Matam	2,681	2,953	3,794	3,582
6	Tambacounda-Kedougou	5,099	5,449	6,409	6,413
7	Bakel	1,869	2,049	2,527	2,464
8	Kaolack-Nioro du Rip	6,549	7,704	8,475	9,325
9	Kaffrine	6,857	8,062	8,888	9,799
10	Tivaouane	5,012	5,529	5,898	6,291
11	Thies	3,644	4,561	5,071	5,637
12	Mbour	2,566	3,131	3,446	3,794
13	Kebember-Louga	4,319	3,528	2,882	2,355
14	Linguere	2,753	3,329	3,791	4,316
15	Gossas-Fatick	6,079	6,321	6,510	6,708
16	Foundiougne	2,751	3,429	3,797	4,205
17	Sedhiou	5,138	5,662	6,722	6,875
18	Kolda-Velingara	4,591	5,059	5,713	6,142
Total		77,665	86,018	94,727	99,779

The current household demand (77,665) for SHS is expected to increase to around 100,000 in the year of 2015. The average growth rate of household demand is estimated to be 1.7 percent.

3.2 Basic Concept of Business Strategy for PV Rural Electrification

Among others, the following items are critical to diffusion of PV system particularly in the initial stage;

A. Overcome the high initial cost barrier: The obstacle of the high initial cost of obtaining energy needs to be removed. Credit mechanisms and/or subsidy provision, lower-cost equipment, and lower service (not lower quality service) standards could all contribute to achieve this objective.

B. Encourage local participation: Participation of local communities, investors, and consumers/beneficiaries (rural population) in the design and delivery of energy services is essential. Decentralized approaches need to be a part of the solution, but they require capacity building of local community.

C. A demand-oriented approach: Based on the belief that solutions to local problems are likely to be more sustainable to the extent that the target communities are able to participate in designing and implementing those solutions. Accordingly, the projects which support implementation of the program's objectives will deliberately reflect needs and requirements as identified by grass-roots communities themselves in close partnership with project promoters, of course requiring an assistance of the government.

Taking into account the above matters, the basic concept of PV rural electrification has been established for this Study.

1. The plan on PV rural electrification for this Study is lighting-oriented scheme as defined below;

   "The electricity use of PV should cover lighting as well as productive use such as water pumping, refrigerator and craft industry. Nevertheless, considering that lighting is the most important purpose of rural electrification, it has been mutually agreed between JICA Study Team and MEH that primal use of PV is the lighting including electric apparatus of household and public facilities (i.e. school, health post, etc.)"

Throughout this discussion the issue of productive uses has not been addressed, but they are not being ignored in this study. We are of opinion that some local economic development will result from the initial electrification initiative. In addition, as people become more aware of the potential of the technology, we expect that there will be a demand for more systems to support local development. The organizational base for the collective action, which has been developed through the household lighting system, will make it possible to support the increased demand. Through the training programs, credit mechanisms, and increased government awareness and social acceptance of these technologies, these programs will expand into the direct economic development arena. Once it is established that rural communities can take part in the formal economic structure, with an understanding and acceptance of credit options, the goal of community empowerment will be achieved.

2. Among the target area for PV rural electrification, there are some locations which may be regarded as transitory stage until they are electrified by other permanent or semi-permanent competitive alternatives such as grid extension, diesel generator grid, etc., which are able to provide sufficient power for value-added income generation as well. In that case, there is high possibility that the PV equipment installed will be transferred to other un-electrified locations in the future.

   In the villages with high electricity needs, the PV system will be shifted to other electricity alternatives. Therefore, it will be required that electrification method should be selected in due consideration of electricity needs and electricity demand.

   In this study, these pre-conditions will be incorporated into the identification of PV target villages which are marginally located at the break-even points between diesel generator priority area and PV priority area. The break-even points are estimated on the basis of the distance from the grid, unit cost per kWh and electricity demand of average household.

3. The target household for PV installation is for those with high annual income, say the upper 20~25% village population. That is, the initial target for PV installation is for those being capable to pay for electricity services. This approach characterizes the study and will be applied for selection of PV priority area. The first priority has been placed on the project sustainability. This development concept is critical to materialization of the rural electrification policy of Senegal, which requires improvement of rural electrification service rate and introduction of private sector initiative.

To meet such requirements, the methodology has been here proposed.

The materialization of "lowering of financial burden on users" and "satisfaction of electricity needs of users" will require both supply-side contribution and demand-side contribution.

The respective contribution is represented by the following:

Supply-side	"Provision of good quality services"
Demand-side	"Financial contribution, called as the initial payment of users being equal to 10% of the initial investment cost" and "Monthly payment" to make the project sustainable.

It should be noted that the risk of fee collection for electricity services is structured to be finally imposed on the Project Operator (the global entrepreneur). That is why most of the financial and technical supports from the government should be directed to the global entrepreneurs, that is, project operators, in the initial stage.

4. The electrification by PV is regarded as lighting-oriented, so that it will not contribute to income generation at the outset. This situation will continue to be only in the initial stage, but the electrification by PV will be expected to be expanded within the village in problem (densification) in a later stage. In parallel with such densification, the income generating activities will be also promoted by introduction of other alternative electrification, but all depending on the business activities of the global entrepreneur in close consultation and collaboration with village community.

As to the financing activities in the regional community. Fund Circulation Mechanisms, should be vitalized and deepened in the rural community. This is a part of the roles played by ASER to create the rural electrification environment/market attractive to the global entrepreneur as well as to the rural population.

The above-mentioned good combination of income generating and financing activities assisted by global entrepreneurs will be expected to proceed in the best case to sustainable rural development.

To materialize such scheme, locally-based entrepreneurs familiar with local socio-economy, local culture and customs, local language, etc., represented by local NGO, PV experts, etc. are expected to play a very important role. The role could be characterized by "Coordinator", which only constructs the reliable relationship among the global entrepreneurs, the rural community, and the rural population.

3.3 PV Business Model

The pilot project is under way in the Mar island. The concept of development for the global PV rural electrification is principally the same as that applied for the pilot project with some exceptions.

In the Mar islands, 100 solar home systems were planned to be installed by a donation of the Japanese Government and owned/supervised by ASER/MEH, while they are managed by the pilot project operator, which happens to be the PV supplier as well. The outline of the pilot project is shown on Table 3.10. The schematic structure for the pilot project implementation is shown on Figure 3.9. The initial investment capital for the 55 Wp solar home systems was donated by the Japan International Cooperation Agency (JICA), under economic assistances program of the Japanese Government. This program also provided training and technical assistance to the ASER/MEH in installation, maintenance, competitive procurement, etc. as well as preparation of PV rural electrification plan.

The pilot project operator charges households an initial payment equal to 10% of the investment cost, and a monthly payment of 3,700 CFA/month being an equivalent of roughly US$6-7 per month, both of which cover direct maintenance costs and replacement capital costs for the batteries, controllers, and light bulbs over a period of 20 years. The pilot project operator is to maintain an interest – bearing account in which the part on the fees are kept to provide financing for future equipment replacement, and include a component to finance PV panel replacement after 20 years.

The program provides a sustainable mechanism for continued maintenance (and perpetual replacement) of donor-supplied systems and provides customers with affordable energy services. However, the scheme is not commercially replicable because it relies on donor-supplied capital equipment to get started. If the company were to finance the initial costs on its own, monthly fees needed to cover these costs would be higher, perhaps at least more than 50%, and some additional financing support would be needed.

In this Section, two strategic options of "Business Model" have been proposed in accordance with the guidelines of ASER.

1) Rural Electrification Priority Program (PPER)
For which ASER provides re-financing and guarantee funds with the financial institutions through annual budget, the fund sources of which are supposed to originate in the international financial institutions such as World Bank/ IDA, etc.

2) Rural Electrification Project by Local Community Initiative (ERIL)
Encouragement or support for rural electrification programs or projects by public or private local community initiative.

Rural Electrification Priority Programs (PPER)

- The implementation of PPER corresponds to the classical "top down approach" of the electricity sector which is well adapted for rural electrification.
- PPER consists of components of PASER: they are defined every year on the basis of the National Rural Electrification Plan fixed by the Ministry of Energy and Hydraulics (MEH) together with some progressive geographical coverage and territory development objectives. Its definition requires the prior establishment of Local Electrification Plan (PLE), that determines for a specific zone the possible rates and the technical option to be adopted to meet such rates.

- Private operators, holders of distribution concessions, whose schedule of conditions include specific objectives in terms of investment plans and service rate. Those operators are selected through annual tender calls. The area of those concessions is delineated so as to guarantee minimum profitability for the operator.

Rural Electrification Project Initiated by Local People (ERIL)

- The Rural Electrification Projects initiated by Local People (ERIL) correspond to the "bottom-up approach" and are not subjected to any previous geographical planning. It can be initiated by:
  - Local Communities, Users' groups, Non-Governmental Organizations (NGO) and
  - Private Operators or Investors

The business model for PPER and ERIL is shown on Figure 3.10.

Table 3.10 Outline of the Pilot Project

The JICA Study on Photovoltaic Rural Electrification Plan

1. **Location:** Mar Lothie, Mar Soulou & Mar Fafako, Prefecture of Fimela, Department of Fatick, Region of Fatick
The three (3) villages are located on the Mar Islands, which could be reached only by an engine boat in about half hour from the town of N'Dangane. N'Dangane is connected to the distribution network of Senelec and is away from Dakar by 2.5 hours drive.

	Mar Lothie	Mar Soulou	Mar Fafako
Population	1,550	886	2,172
No. of concessions	197	39	186
Economic Activities	Agriculture, Livestock, Fishery, remittance	Agriculture, Livestock, Fishery, remittance	Agriculture, Livestock, Fishery, remittance

2. **Executing Agency:** l'Agence Senégalaise d'Electrification Rurale (ASER), Ministry of Energy and Hydraulic (MEH)
3. PV Supplier: MATFORCE
4. Number of PV system to be purchased: 100 units
5. Initial Number of PV installation: 94 units
6. Service Period: 20 years
7. Component of PV system
PV Panel: 55 Wp
Charge controller: 10A
Battery: 100 Ah

Type 1	Type 2	Type 3
Lighting-oriented system	TV-oriented system	TV and lighting-oriented system
5 LFC lumps 1 socket for a radio	3 LFC lumps 1 socket for a radio 1 socket for a black-white TV	2 LFC lumps 1 socket for a radio 1 socket for a black-white TV LED lumps

8. "Fee for Services" for users
Initial Payment: 45,000 CFA
Monthly Payment: 3,700 CFA

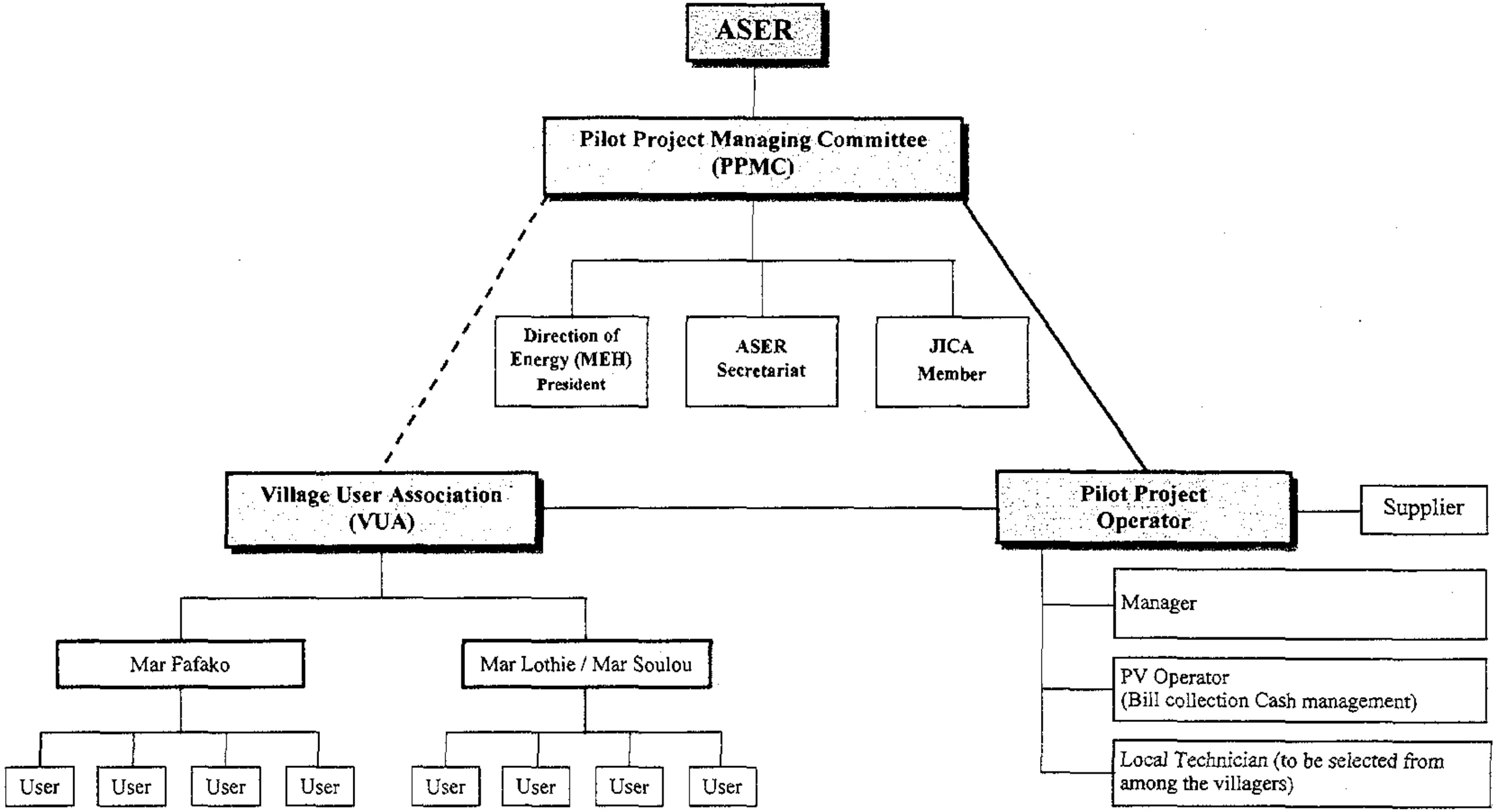


Figure 3.9 Schematic Structure for Management of Pilot Project

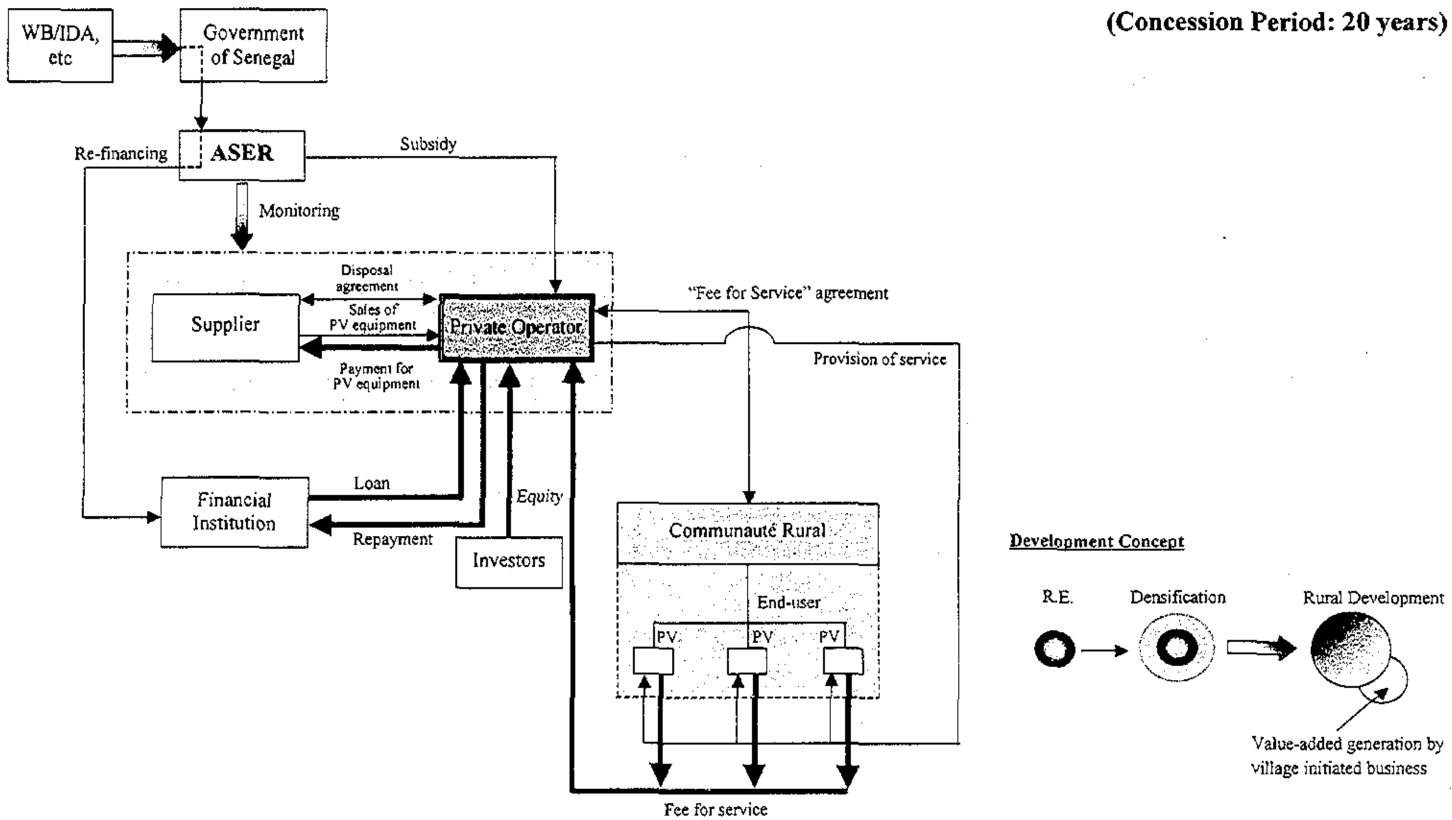


Figure 3.10 Business Model (PPER/ERIL)

Total Management by Private Operator under Local Community Initiative

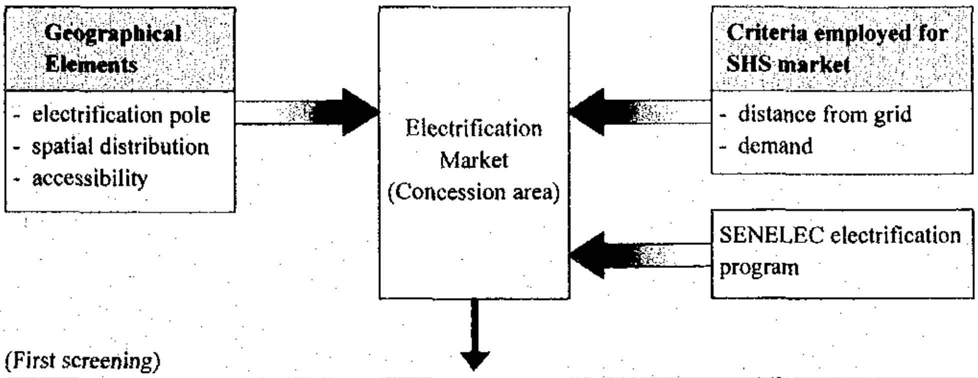
3.4 Rural Electrification Programs for PV (SHS)

(1) Premises for SHS Market

The theoretical approach to identification of villages having potential demand for SHS is demonstrated in Figure 3.6. Potential market (the distribution of villagers) is presented in terms of I) distance from existing grid and (ii) demand (household). The approach would be fundamentally appropriate for the scheduled Local Electrification Plan of 3 concession areas (Dagana-Podor, Mbour, Kolda-Velingara) in the first tranche where electrification market for technical options (extension of MV line, LV network, PV) is to be clarified. Nevertheless, the market for respective option would be determined taking into consideration the following criteria given below:

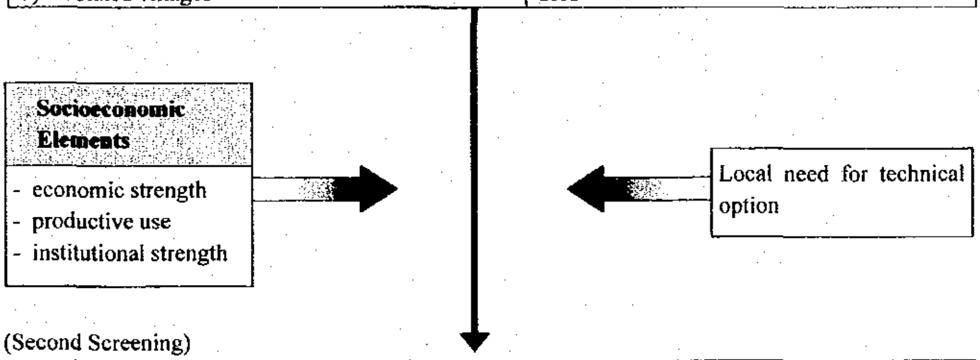
Criteria	Criteria Conditions
a) Electrification center	• Distribution of community rurals' center • *Potential demand for electrification at centers of CRs*
b) Spatial distribution of villages	• Distribution of satellite villages around centers of CRs • Distribution of villages along existing grid line
c) Accessibility	• Roads' network with road surface conditions • Accessibility to centers of Departments
d) Economic strength of villages	• Fertile condition of farm land • Share of non-agricultural income sources
e) Productive use of electricity	• Size of harvested area by crop • Production possibility of agricultural-processed products
f) Institutional strength of villages	• Existence of local entrepreneur or NGOs • Invalvement of village organization in water supply, primary health care and social activities • Involvement of women in existing social activities

The criteria is largely classified into two elements; namely I) geographical element covering from a) to c) and ii) socioeconomic element covering from d) to f). The point is how to use criteria in order to identify potential market for respective technical option. Perhaps the survey is firstly to be made for geographical element in order to have a rough idea of villages to be electrified and technical captions for them. Secondly socioeconomic element is taken into account in order to determine villages with the appropriate options to be electrified. The concep0tual flow of market screening for technical options is as follows:



(First screening)

Potential Market	Options
1) First category of community rural centers	MV extension with LV network
2) Second category of community rural centers	D/G based mini grid
3) Third category of community rural centers	D/G or SHS or a combination of them
4) Satellite villages around community rural centers of the first category	LV extension
5) Satellite village around community rural centers of the second and third categories	SHS
6) villages along existing grid line	LV extension or SHS
7) Isolated villages	SHS



(Second Screening)

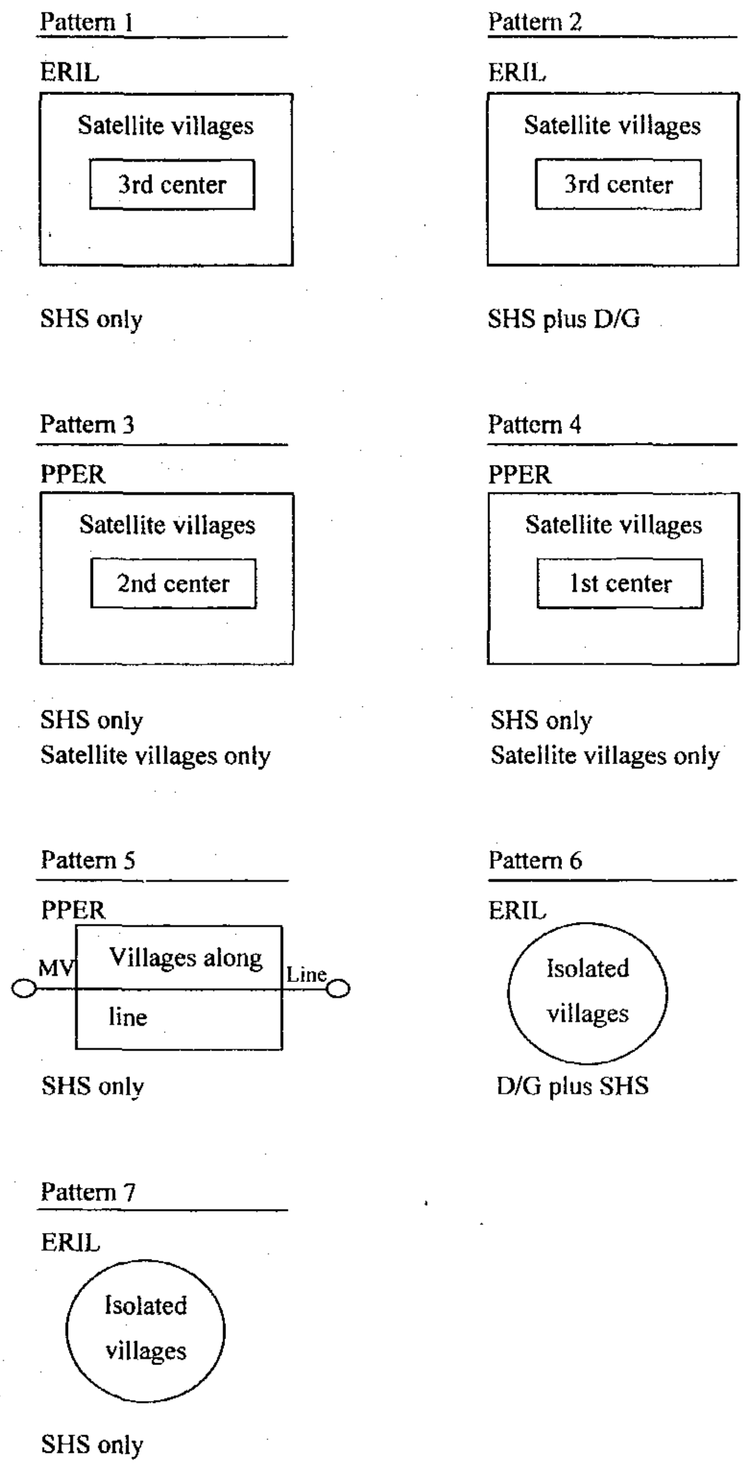
Group	Market	Options	Modes
1	First category of CR centers	MN extension with LV	SENELEC
2	- ditto -	- ditto -	PPER
3	Second category of CR centers	D/G-based mini grid	PPER or ERIL
4	Third category of CR centers	D/G-based mini grid	PPER or ERIL
5	- ditto -	SHS	ERIL
6	- ditto -	D/G with SHS	ERIL
7	Satellite villages around the first category of CR centers	LV extension	PPER
8	- ditto -	SHS	PPER
9	Satellite villages around the 2nd and 3rd categories of CR centers	SHS	ERIL or PPER
10	Villages along existing grid	LV extension	PPER
11	- ditto -	SHS	PPER
12	Isoalted villages	D/G with SHS	ERIL
13	- ditto -	SHS	ERIL

In the first screening, RE market is broadly divided into centers of CRs, satellite villages around centers of CRs, villages along existing grid, and isolated villages. Centers of CRs are basically regarded as poles of rural electrification. Those centers are further sorted out into 1st, 2nd and 3rd categories according to population, accessibility and the short-term grid extension plan of SENELEC. The range of population by category is perhaps I) (P>2,000) for 1st category, ii) (1,000<P<2,000) for 2nd, and iii) (P<1,000) for 3rd. The centers having good accessibility to region and department capitals with paved roads are grouped into 1st and 2nd whereas the centers with poor accessibility are regarded as 3rd. Satellite villages are also classified into those around the first category's centers and those ground 2nd and 3rd centers. Finally, taking into account criteria expressed by distance from existing grid and size of demand (household), technical options are implicitly determined for 7 groups of RE market in the first screening.

In the second screening, seven (7) market groups screened at the first stage can be further classified into 13 groups taking into account socioeconomic criteria and local needs for electrification options. The split of 7 into 13 groups in relation to the criteria employed is schematically illustrated below:

1st Screening	2nd Screening	Main Criteria Employed
1st category of CR centers	Group 1	• Potential users (more than 60) with high income
	Group 2	• The above criteria but outside of SENELEC plan
3rd category of CR centers	Group 4	• High possibility of productive use of electricity • Existence of local entrepreneur or NGOs • Relatively high economic strength of villages
	Group 5	• Existence of local entrepreneur or NGOs • Experience of village organization in social activities
	Group 6	• Relatively high possibility of productive use of electricity • Existence of local entrepreneur • Experience of village organizations in social activities
Satellite villages Around 1st center	Group 7	• Potential users (more than 30) plus local preference
	Group 8	• Potential users (less than 30)
Villages along existing line	Group 10	• Potential users (more than 30) plus local preference
	Group 11	• Potential users (less than 30)
Isolated villages	Group 12	• The same as Group 6
	Group 13	• The same as Group 5

In conclusion, SHS market including RE modes is illustrated below:

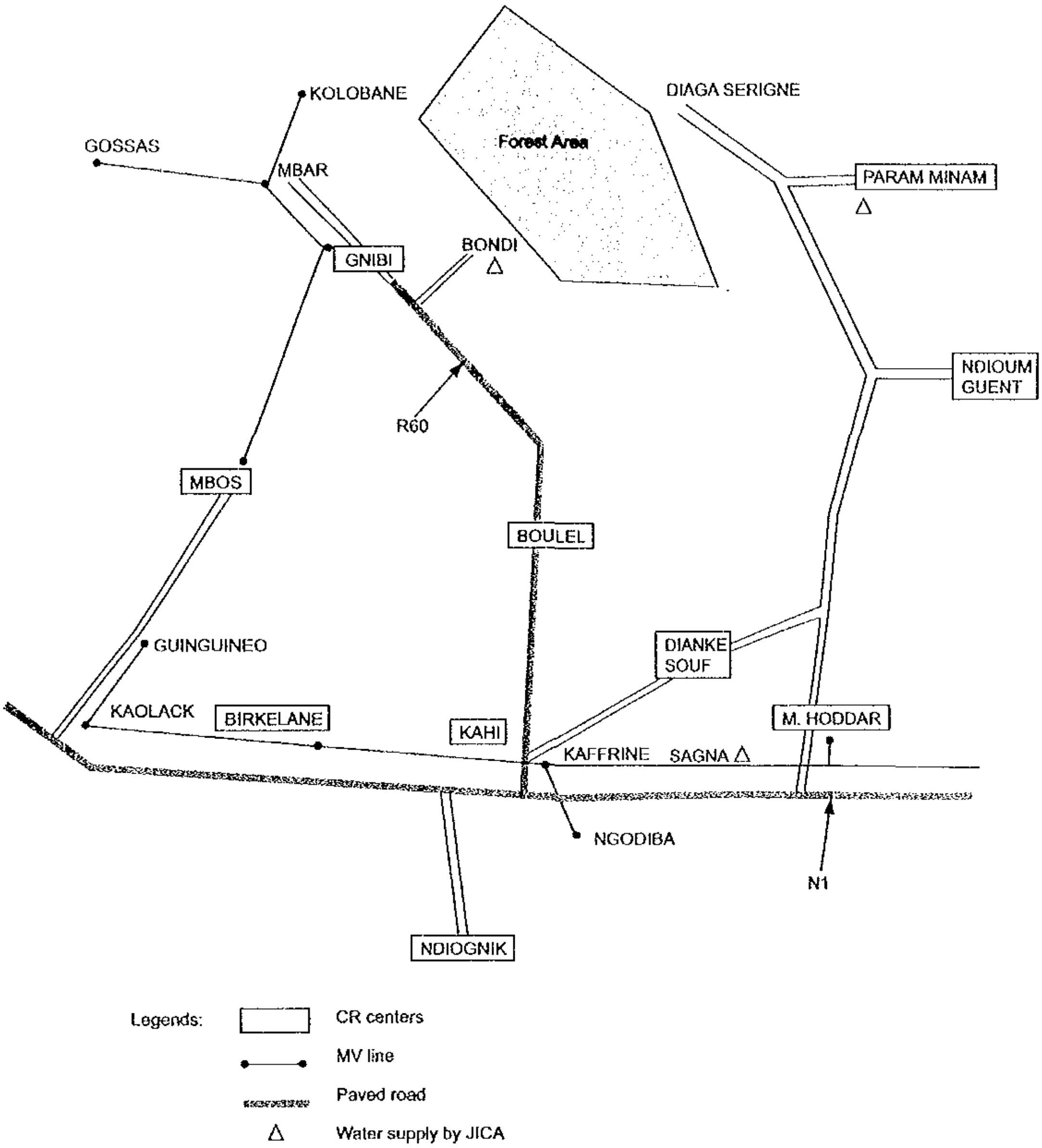


(2) Application of SHS Market Concept

The JICA Study team made a reconnaissance survey of a concession area with a ASER staff during October 8~9 in order to grasp a rough idea of the electrification market concept discussed so far. Kaffrine in the region of Kaolack as tentatively selected with the following reasons.

- Kaffrine is a densely populated area consisting of the different size of community rural centers in terms of population.
- The existing MV line was constructed along the national road marked by N1.
- The road 60 penetrates into the area in the north-south direction, connecting Kaffrine to Mbake (Diourbel region), thereby accessibility to community rural centers along R60 is completely good whereas accessibility to other community rural centers is geographically hampered by non-paved roads with bad road surface condition.
- Forestry area is dominant in the northern part of Kaffrine so that some villages are land-locked.
- Some villages are equipped with water supply facilities granted by the bilateral donor (Japan), thereby these villages' organizations are relatively well-trained in the light of operation and management of social and economic services.
- Kaffrine is still a dominant area with groundnut production, also endowed with a variety of crops so that the prospect for productive use of electricity would be possible for a collective harvesting or possibly agricultural products.

The reconnaissance survey covers two arrondisments called Birkelane and Maleme Hoddar consisting of community rurals. The location map is roughly sketched below:



SHS market in surveyed area is presumed to be as follows:

Location	Pattern	SHS market	RE mode	Remarks	Potential Users
GNIBI	4	Satellite	PPER	The center electrified by SENELEC	300~400
MBOS	4	Satellite	PPER	- ditto -	300~400
BOULEL	3	Satellite	PPER	The center to be electrified by D/G	200~300
KAHI	5	Entire CR	PPER	KAHI is located in existing MV line	100~150
DIANKE SOVF	1	Center + satellite	ERIL	Accessibility to the center is bad	150~200
M. HODDAR	4	Satellite	PPER	Accessibility to the center is bad	300~400
N. GUENT	2	Center + satellite	ERIL	Productive use is relatively high	200~250
D. MINAM	2	Center + Satellite	ERIL	Productive use plus water supply	200~250
BONDI	2	Village	ERIL	Productive plus water supply	150~200
D. SERIGNE	7	Village	ERIL	Land-locked village	30~50

Potential users of SHS are identified in satellite villages around centers of the community rurals of the first to second category, concentrating on the pattern 3 and 4 to be electrified by PPER. Potential users in satellite villages per community rural is approximately assumed to be 200 to 400.

SHS users are also identified in center of community rural with satellite villages, concentrating on the pattern 1 and 2 to be electrified by ERIL. Accessibility to these community rurals is relatively bad. Diesel would be used for productive use only while SHS is to be demanded for lighting mainly. Potential users of SHS per community rural are estimated to be 150 to 250.

One community rural adjacent to the existing MV line would be potential market of SHS. Villages are scattered along the line, to be electrified by PPER. Potential users of SHS are estimated to be around 100 to 150.

Finally potential users are identified in land-locked village, far from the major town Kaffrine. Local need for electrification is positive, so that ERIL-based electrification using SHS could be recommendable. Potential users are estimated to be 30 to 50.

(3) Project

The preliminary survey of Kaffrine indicates the potential number of rural households to be electrified by SHS in accordance with RE modes (PPER or ERIL).

Community Rural	Mode	SHS Users According to Patterns								
		1	2	3	4	5	6	7	Max	Min
MBOS	PPER				300-400				400	300
GNIBI	PPER				300-400				400	300
BOULEL	PPER/ ERIL		200-250	200-300					550	400
KAHI	PPER					100-150			150	100
DIANKE SOUF	ERIL	150-200							200	150
M. HODDARr	PPER				300-400				400	300
N. GUENT	ERIL		200-250						250	200
D. MINAM	ERIL		200-250					30-50	300	230
Total									2,650	1,980

The term "potential users" means potential households to be electrified by SHS. They are estimated to be 2,650 at maximum and 1,980 at minimum in the survey area. The future SHS-based RE would be probably implemented on the basis of community rural. Perhaps a community rural might be the least unit to formulate a SHS project. The average scale of SHS users per project (or per community rural) in the survey area is estimated to be 330 at maximum and 250 at minimum. Perhaps such a range of project scale is assumed to be under annual capacity of a concession-holder of PPER or ERIL. In this study, the average scale of a project is assumed to be 300 on the average.

(4) RE Programs of SHS

All Senegal is divided into 18 concession areas. The implicit order of tender call for concession areas is supposed to be:

No comprehensive explanation is made in the Manual as to how such a schedule is strategically formulated. In fact, the capacity-to-pay of users for electricity service is the most determinant factor for successful implementation of a concession-based RE. This is why the area of Dagana-Podor, endowed with rich users-to-be, was scheduled for the first tender call. Velingara-Kolda is to be under the scheme of French development assistance. The implementation order of tender call for concession would depend on socio-economic or external factors.

Year	Tentative Schedule of Tender Call
2001	1) Dagana-Podor, 2) Mbour, 3) Velingara-Kolda
2002	4) Foundiaugne, 5) Kaolack-Nioro du Rip, 6) Sedhiou
2003	7) Matam, 8) Bakel, 9) Ziguinchor
2004	10) Tivaouane, 11) Keemer-Louga, 12) Dioubel-Bambay
2005	13) Tambacounda-Kedougou, 14) Kaffrine, 15) Gasas-Fatick
2006	16) Linguere, 17) Mback, 18) Thies

The SHS-based RE is assumed to be implemented with the following conditions:

1) The long-term development of RE is 15 years from 2001 to 2015. After tender call, RE will be continuously implemented during the development phase.

2) At least, a SHS-based RE project is to be implemented annually under the modes of either PPER or ERIL.

3) Annual capacity of concession-holder to handle new SHS subscribers per project is assumed to be 300 on the average, whereas such an annual capacity could be for lower in areas where demand diminishes in the future (No. 7 and 13).

4) In case the number of CRs is quite limited with a growing demand (No. 12), projects would be implemented more than two time per CR during 2001-15. Annual capacity is accordingly lower than 300.

No.	Region	Departments	Implementation	Nos of CRs Electrified	Nos of CRs in area	SHS RE Programmed	Demand (2015)
1	Ziguinchor	Bignona-Oussouye-Ziguinchor	04-15 (12)	12	24	3,600	5,355
2	Diourbel	Diourbel-Bambay	05-15 (11)	11	22	3,300	8,340
3	Diourbel	Mbacke	07-15 (9)	9	11	2,700	3,961
4	St. Louis	Dagana-Podor	02-15 (14)	14	16	4,200	4,217
5	St. Louis	Matam	04-15 (12)	12	12	3,600	3,582
6	Tambacounda	Tamba-Kedougou	06-15 (10)	10	23	3,000	6,413
7	Tambacounda	Bakel	04-15 (12)	10	10	2,460	2,464
8	Kaolack	Kaolack-Nioro du Rip	03-15 (13)	13	20	3,900	9,325
9	Kaolack	Kaffrine	06-15 (10)	10	21	3,000	9,799
10	Thies	Tivouane	05-15 (11)	11	14	3,300	6,291
11	Thies	Ties	07-15 (9)	9	9	2,700	5,637
12	Thies	Mbour	02-15 (14)	8	8	3,780	3,794
13	Louga	Kebemer-Louga	05-15 (11)	11	31	2,355	2,355
14	Louga	Linguere	07-15 (9)	9	17	2,700	4,316
15	Fatick	Gassas-Fatick	06-15 (10)	10	26	3,000	6,708
16	Fatick	Foundiougne	03-15 (13)	13	9	3,900	4,205
17	Kolda	Sedihiou	03-15 (13)	13	20	3,900	6,875
18	Kolda	Kolda-Velingara	02-15 (14)	14	23	4,200	6,142

The term "SHS RE programmed" means the number of households to be electrified by SHS during implementation period. This is simply calculated by a multiplication of the average connection rate (300) per year with implementation period. Thus in some connection areas, the figure of SHS RE programmed is close to or surpass demand (2015) projected. This is partly because the number of CRs in concession area is fewer than that of CRs scheduled for RE implementation and partly because the demand for SHS diminishes in proportion to the decrease of population. These correspond to the concession areas of 7, 12, 13, 16. In these areas, the demand is the upper limit of SHS RE programmed. The SHS RE programmed on the basis of year-by-year is shown in Table 3.11.

Launching Stage

As of the year 2005, the number of households to be electrified by SHS is estimated to be about 8,700 while the number of CRs electrified by SHS is expected to be 30. Electrification of 8,700 households corresponds to 10% of potential demand (86,000) of SHS as of the year 2005. The appears to be less-performed, compared to the target (17,000) of PV RE proposed by the PASER.

Consolidation Stage

The number of households to be electrified by SHS is estimated to be about 60,000as of the year 2015, which corresponds to about 59% of potential demand (99,800) as of the year 2015. Electrification of 59,500 households will be les than the target (70,000) of PV RE proposed by the PASER. The number of CRs to be electrified turns out to be 199, which corresponds to 62% of the whole CRs.

Table 3.11 SHS Rural Electrification Programs

Concession	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	
1				300												3,600
2					300											3,300
3							300									2,700
4		300														4,200
5				300												3,600
6						300										3,000
7				240												2,880
8			300													3,900
9						300										3,000
10					300											3,300
11							300									2,700
12		270														3,780
13					214											2,355
14							300									2,700
15						300										3,000
16			300													3,900
17			300													3,900
18		300														4,200
		870	1,770	2,610	3,424	4,324	5,224									60,015

3.5 Financial Plan

The objectives of financial analysis are clearly different, depending on the role of stakeholders involved in implementation of RE. A concessionaire (private operator) would take interest in return of equity (ROE), and financial institutions definitely secure certaintly that both principal and interest are to be repaid as scheduled, given loan conditions. ASER as the government organ to give permission of RE business to concessionaires, will be responsible for selection of them and have to determine subsidy amount based on financial proposal, with an approval of the proposed pricing for "fee for services".

(1) Basic Conditions of Financial Analysis

The basic concept of the project formulation has been proposed in the previous section, which is based on and in accordance with the principle policy of ASER.

Referring to the role of the respective stakeholder, the basic conditions for financial analysis are as follows;

1) System Unit Cost

The majority of household demand for SHS is identified to be 55Wp. Financial analysis focuses on a unit of 55Wp, the cost of which is 450,000 FCFA.

2) Capacity to Pay

The monthly payment corresponding to "capacity to pay" depending on the average monthly expenditures for electricity-related appliances can be estimated by referring to the Nationwide Socio Economic Survey as a component of the JICA Study. Expenditures of energy items consumed by non-electrified village households (1,483 samples) are presented in Table 3.12. The whole samples (1,483) are divided into those by income class whose classification is the same as that employed to identify share of SHS users in income distribution. Yearly and monthly expenditures indicate the average figures of respective income class.

Table 3.12 Expenditures of Energy Items (Sample Survey)

Annual income category (,000FCFA)	Non-electrified village households		Cumulative (%) of income distribution	Annual expenditures of energy items (FCFA)	Monthly expenditures (FCFA)
< 300	488	(32.9)	32.9	24,989	2,082
300 to 600	96	(6.5)	39.4	29,066	2,422
600 to 800	425	(28.6)	68.0	37,907	3,158
800 to 1,000	155	(10.5)	78.5	49,310	4,109
1,000 to 2,000	126	(8.5)	87.0	63,702	5,308
2,000 to 3,000	156	(10.5)	97.5	66,922	5,576
3000 <	37	(2.5)	100.0	85,248	7,104
	1,483	(100.0)			

Source: Sample data of the Nationwide Socio Economic Survey (JICA)

Suppose that the share of SHS users-to-be in the upper income classes ranges 20 to 25%, they would belong to income brackets ranging from (1,000,000 to 2,000,000 FCFA) to (> 3,000,000 FCFA). The number of sample households covering these income categories is 319, sharing about 22% of the whole samples. The monthly average expenditure of energy items of 319 samples is estimated to range between 5,000 CFA and 7,000 FCFA. The result indicates that the willingness-to-pay is averagely estimated to be around 5,000-6,000 FCFA nationwide. The willingness-to-pay is, of course, different by area, depending on energy expenditures and share of SHS users-to-be in income distribution. In this financial analysis, the range of monthly payment is assumed to be from 4,000 to 6,000 FCFA.

3) Scale of subscribers per project

The number of subscribers (installation units) covered by one project mostly ranges from 100 to 500, depending on size of population in community rurals. The scale of subscribers per project is assumed to be 100, 300 and 500.

4) Annual O&M expenses

Operation and maintenance cost per unit is assumed to diminish as the scale of subscribers increases. Annual O&M cost as % of initial investment cost by scale of subscribers is given below:

100 units : 4.6%

300 units : 3.8%

500 units : 3.4%

5) Users' Contribution

Financial contribution	:	10% of the initial cost, called as "Initial Payment"
Institutional set-up	:	Establishment of village users association, called as VUA, under the initiative of the village community
Payment method	:	Monthly Payment shall be fixed by the operator subject to ASER's approval

6) Operator's Proposal

Operator's equity	:	15~20% at minimum, more than the users' contribution
Loan portion	:	Concessionaire loan from local financial institution financially supported by ASER
Subsidy proposal	:	Proposed as % of the initial investment cost with socio-economic analysis results for the target villages, referring to willingness to pay and capacity to pay
Structuring of VUA		Training schedule of technician of village community Method of bill collection and fee for technicians Maintenance supporting system
Cash-flow management		Secure the amount to be required for renewal of all equipment during the concession period of 20 years (tentative)

7) Role of ASER

Assessment of the proposal to be submitted by the operator

Selection criteria	ROE which be ranged between 15 and 20% (Provisional)

The pricing for "Fee for Services", such as initial payment and monthly payment, may be proposed under the following conditions;

1. Equity portion as % of the initial cost

2. Users' contribution as % of the initial cost
3. Loan amount and loan conditions such as interest, repayment period and grace period
4. Subsidy portion of % of the initial cost
5. Project management structure

(2) Financial Analysis

The financial analysis has been carried out based on the pre-conditions as shown on Table 3.13. The calculation format is shown on annex A, in which the income statements, the cash-flow statements, and the balance sheets are presented over a concession period of 20 years.

The monthly payment, which corresponds to "Capacity to pay" depending on the average monthly expenditures for electricity-related appliances, shall be determined in due consideration of socio-economic conditions in the target village. On the other hand, the initial payment corresponding to 10% of the investment cost, is regarded as a pre-condition for initiation of this scheme.

At this moment, the following indicators may be provisionally adopted for preparation of the financial analysis. At the same time, Chart 3.1 should be referred.

Subsidy Rate	Fee	ROE	Cash Position After 20 years	Fee After 5 years	%	ROE	Cash Position After 20 years
50%	4,650	10.1%	-53.7 Million CFA	5,441	17%	16.9%	0.9 Million CFA
50%	4,890	15.0%	-29.5 Million CFA	5,379	10%	18.9%	4.2 Million CFA
50%	5,130	20.0%	-5.3 Million CFA	5,233	2%	20.8%	1.8 Million CFA

The major parameters used for analysis of FIRR and ROE and defined as follows;

FIRR: the internal rate of return on investment is determined as the discount rate that equalizes the present value of the streams of financial costs represented by capital investment, say "cash outflow" and profits represented by turnover minus operating cost, say "cash inflow" over a period of the project life.

ROE: the internal rate of return on equity, is determined as the discount rate that equalizes the present value of the streams of financial costs represented by investor's equity, say "cash outflow" and profits represented by net income after tax plus (depreciation + amortization), say "cash outflow" in the international accounting standards, over a period of the project life.

(3) Financial Plan

ASER will be financially required to support implementation of SHS RE during 2001 – 2015. Here, to meet the policy target of ASER, the total PV units to be installed until the year of 2015 is estimated to be about 70,000. The financial requirement is estimated under the following assumptions;

1. Capacity of SHS PV system		55	Wp
2. Present unit price of SHS PV system		450,000	CFA
3. Exchange rate (against US$)		750	CFA/US$
4. Capital structure			
Operator's equity		20	%
User's contribution		10	%
ASER's financial support		70	%
Subsidy		(50	%)
Loan		(20	%)
5. Devaluation growth of CFA	Case I		0% p.a.
(No change of exchange rate is applied for the years after 2011)	Case II		3% p.a.
	Case III		5% p.a.

In this analysis, the capacity of SHS PV system is assumed to be 55 wp, which is recognized to be rather popular in the developing countries and as well in Senegal.

The outputs are presented as total amount required to support the diffusion of SHS PV system over a period of 200-2015 and meet the policy target of ASER.

The summary results of the financial plan are presented as below:

	Case I	Case II	Case III
Devaluation value	0% p.a.	3% p.a.	5% p.a.
Total amount (Million CFA)	26,460	33,795	39,726
Total amount (Thousand US$)	35,280	35,280	35,280

In the case III for the annual growth, 5% of currency devaluation, the accumulated financial support of ASER, including the technical support supposed to be equal to 20% of the financial support, has been estimated at about 39.7 million CFA, in which the exchange rate is 750 CFA/US$ and 1,222 CFA/US$ for 2000 and 2010, respectively. As far as the financial plan is concerned, the diagrams in Chart 3.3 should also be referred.

As shown on the above results, the total amount required to meet the policy target of ASER will be influenced greatly by the exchange rate of CFA against US$, the former of which is rigidly linked to the french francs, eventually to the currency of Euro.

As discussed in the subsequent section, the PV market in Senegal is very susceptible to the external economic and technology development. The management of currency exchange rate is beyond the power of ASER, even the government of Senegal. Therefore, it should be noted that the PV rural electrification is not a domestic matter and the implementation will be significantly affected by the external economic development, particularly the change in currency valuation.

Table 3.13 Pre-Conditions for Financial Analysis

1	Initial Investment Cost	135	Million CFA
2	Users' Financial Contribution (equal to Initial Payment)	10%	of 2. Initial Investment Cost
3	Operator's Equity	20%	of 2. Initial Investment Cost
4	Annual O & M expenses		
	100 Units	4.6%	of 2. Initial Investment Cost
	300 Units	3.8%	of 2. Initial Investment Cost
	500 Units	3.4%	of 2. Initial Investment Cost
6	Replacement Period		
	PV Module	20	years
	Charge Controller	10	years
	Battery	4	years
7	Interest Rate of Bank Loan	7%	
8	Interest Rate for Saving Deposit	4.25%	

Chart 3.1 Operation & Management by the Operator over a Concession Period of 20 Years

Chart 3.1 Operation & Management by the Operator over a Concession Period of 20 years

General Pre-Conditions

System Unit (55 Wp)	300	Units
System Unit Cost	450,000	CFA
Replacement Cost	135.0	Million CFA after 20 years' operation

Fee for Service

Period (Year)	Up to 5	6 to 10	11 to 20
Tariff (CFA/month)	*5,130*	*5,233*	*5,233*
		2%	2%

Initial Payment

45,000 CFA/Unit

Replacement cost secured after 20 years

Case Study

Subsidy Rate	ROE	Cash Position After 20 years		Fee for Service (CFA/month) Up to 5	5 to 10	10 to 20
50%	20.8%	1.8	Million CFA	5,130	5,233	5,233

Summary Results

Subsidy Rate	Fee	ROE	Cash Position after 20 years		Fee after 5 years	%	ROE	Cash Position after 20 years	
50%	4,650	10.1%	-53.7	Million CFA	5,441	17%	16.9%	0.9	Million CFA
50%	4,690	15.0%	-29.5	Million CFA	5,379	10%	18.9%	4.2	Million CFA
50%	5,130	20.0%	-5.3	Million CFA	5,233	2%	20.8%	1.8	Million CFA

30%	5,920	20.1%	8.6	Million CFA	5,802	-2%	19.1%	0.4	Million CFA
30%	5,670	15.0%	-16.6	Million CFA	5,954	5%	17.3%	2.9	Million CFA

Subsidy = 50%
ROE = 20%
Cash Position on the positive side after 20 years

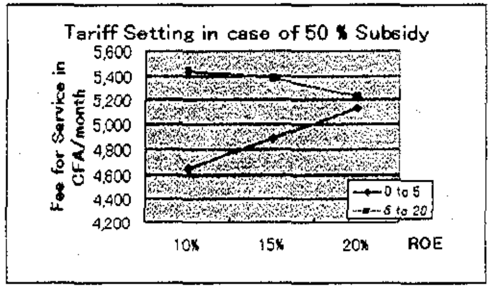
Units	Fee for Service 0 to 5	6 to 20	Cash position after 20 yea	ROE	ROE
100	5,600	5,655	0.6	20.8%	21.2%
300	5,130	5,233	1.8	20.0%	20.6%
500	5,000	5,150	4.5	19.9%	21.1%

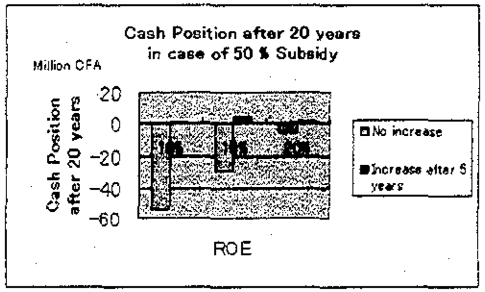
Tariff setting for 50% subsidy

	0 to 5	6 to 20
10%	4,650	5,441
15%	4,890	5,379
20%	5,130	5,233

Cash Position after 20 years

	No increase	Increase after 5 years
10%	-53.7	0.9
15%	-29.5	4.2
20%	-5.3	1.8





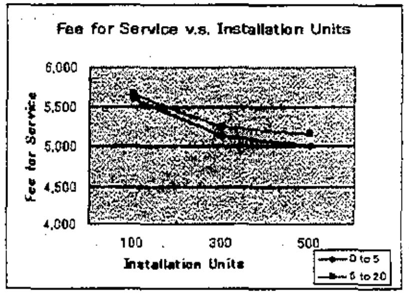


Chart 3.2 (1) Financial Business Model for PV Rural Electrification

1 English, 0 French (In case of no liquidation)

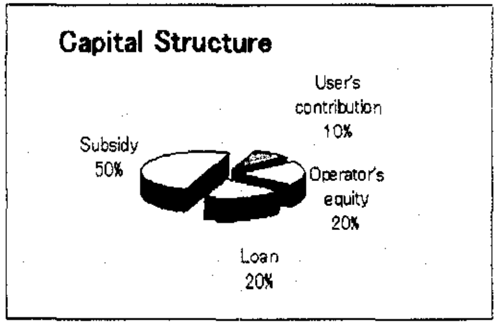
Pre-Conditions

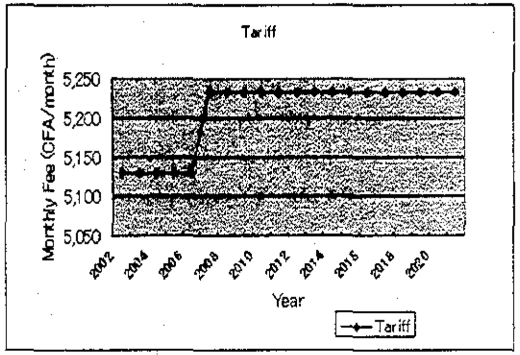
1 System Unit Cost (55 Wp) **450** (1,000 FCFA)

2 O & M Cost for Private Operator — See "O & M and Renewal"

3 Capital Structure

Initial Investment Cost	135,000	0.21	US$ million
User's contribution	10%	13,500	
Operator's equity	20%	27,000	
Loan	20%	27,000	
Interest	7.0%		
Repayment	5,400 x 1,000 CFA/year		
Grace period	5 years		
Repayment period	10 years		





94,500 Amount (= Subsidy + Loan)

Subsidy 50% 67,500 — **ROE** = [ ] over a period of 10 years for the operator's profitability — 0 Profit at sales

4 Others — **ROE** = 20.8% over a period of 20 years for the operator's profitability without liquidation

Depreciation method: A straight-line method — FIRR = 0.9%

Income tax rate: 0%

5 Tariff

up to 2006	up to 2011	after 2012
0%	2%	2%
5,130	5,233	5,233

Tariff setting after 10 years ← Increase in tariff after 10 years

45,000 FCFA — For the initial payment which may be regarded as 'User's Contribution'

OK **5,130** FCFA/Unit/month — For the monthly payment

660,600 (Total amount of user's payment for 10 years)

11,466	Minimum Accu. Cashflow
22,598	Cash Position after 10 years
0	For equity liquidation

31,425	Minimum Acc. Cashflow
1,790	Cash Position after 20 year

after reduction of the replacement cost — 136.8

6 No. of Subscribers: **300** Units

, where the amount required for replacement be secured, say, **135.0** Million CFA

31,425 *to secure the cash position on the plus side over a period of 20 years*

7 Depreciation (US$ = 650 FCFA)

FCFA/System	Life	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2021
												1	1	1	1	1	1	1
Depreciation		14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670

Chart 3.2 (2) Financial Business Model for PV Rural Electrification

I, L	8	**Projection of Income**																				
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
		Fee Collection Rate		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
		Revenue		18,468	18,468	18,468	18,468	18,468	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837	18,837
		Expenses Direct cost		5,112	5,112	5,112	3,600	3,600	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024
		Gross Profit	0	*13,356*	*13,356*	*13,356*	*14,868*	*14,868*	*15,813*	*15,813*	*15,813*	*15,813*	*15,813*	*15,813*	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813	15,813
		Depreciation		14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670
		Interest	0	1,890	1,890	1,890	1,890	1,890	1,890	1,512	1,134	756	378	0	0	0	0	0	0	0	0	0	0
		Net Profit	0	-3,204	-3,204	-3,204	-1,692	-1,692	-747	-369	9	387	765	1,143	1,143	1,143	1,143	1,143	1,143	1,143	1,143	1,143	1,143
		Income tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Minimum income tax	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Net Income	0	-3,204	-3,204	-3,204	-1,692	-1,692	-747	-369	9	387	765	*1,143*	*1,143*	*1,143*	*1,143*	*1,143*	*1,143*	*1,143*	*1,143*	*1,143*	*1,143*
		Accumulated Profit	0	-3,204	-6,408	-9,612	-11,304	-12,996	-13,743	-14,111	-14,102	-13,715	-12,949	-11,806	-10,662	-9,519	-8,376	-7,232	-6,089	-4,946	-3,802	-2,659	-1,516
J		**Debt Financing**	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
		Loan at beg		27,000	27,000	27,000	27,000	27,000	27,000	21,600	16,200	10,800	5,400	0	0	0	0	0	0	0	0	0	0
		Repayment							5,400	5,400	5,400	5,400	5,400										
		Interest	0	1,890	1,890	1,890	1,890	1,890	1,890	1,512	1,134	756	378	0	0	0	0	0	0	0	0	0	0
		Loan at end	27,000	27,000	27,000	27,000	27,000	27,000	21,600	16,200	10,800	5,400	0										
H		**Cash-Flow Stream**	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
		Net income	0	-3,204	-3,204	-3,204	-1,692	-1,692	-747	-369	9	387	765	1,143	1,143	1,143	1,143	1,143	1,143	1,143	1,143	1,143	1,143
	plus	Depreciation	0	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670	14,670
	plus	User's contribution	13,500																				
	plus	Equity	27,000										0										
	plus	Additional equity (Workii	0										0			0							
	plus	Loan	27,000																				
	plus	Subsidy	67,500																				
	minus	Repayment	0	0	0	0	0	0	5,400	5,400	5,400	5,400	5,400	0	0	0	0	0	0	0	0	0	0
	minus	Initial Investment	135,000										**100%**										
	minus	**Replacement**		0	0	0	24,900	15,600	0	0	24,900	0	**27,600**	0	24,900	0	0	15,600	24,900	0	0	0	0
G		PV Module (Wp)	180,000																				54,000
		Charge controller (A)	40,000										12,000										12,000
		Battery (Ah)	83,000				24,900				24,900				24,900				24,900				24,900
		Lamps	*52,000*					*15,600*					*15,600*					15,600					15,600
		Pole, Cable, etc.	60,000																				18,000
		Installation, Transport	35,000																				10,500
		Profit for Supplier	0																				

Chart 3.2 (3) Financial Business Model for PV Rural Electrification

			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
			450,000																				
H	Net Cashflow		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
			0	11,466	11,466	11,466	-11,922	-2,622	8,523	8,901	-15,621	9,657	-17,565	15,813	-9,087	15,813	15,813	213	-9,087	15,813	15,813	15,813	15,813
		Accu. Cashflow	0	11,466	22,932	34,398	22,476	19,854	28,377	37,279	21,658	31,315	13,751	29,564	20,478	36,291	52,104	52,318	43,231	59,044	74,858	90,671	106,484
	Deposit bank rate	4.25%		11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	79,347	97,858	116,998	136,790
	% of the outstanding amount	80%			2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
			-27,000	11,466	11,466	11,466	-11,922	-2,622	8,523	8,901	-15,621	9,657	-17,565	15,813	-9,087	15,813	15,813	213	-9,087	15,813	15,813	15,813	15,813
		Equity Portion	-27,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
80%	Bank deposit effect for 80% of the outstandings			0	390	793	1,210	846	785	1,102	1,442	960	1,321	768	1,332	1,068	1,642	2,236	2,319	2,089	2,698	3,327	3,978
	at the beg. of the year	Real Cash-Flow	-27,000	11,466	11,856	12,259	-10,712	-1,776	9,308	10,003	-14,179	10,617	-16,244	16,582	-7,755	16,882	17,456	2,449	-6,767	17,902	18,511	19,141	19,791
	Operator's ROE =	20.8%		11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	79,347	97,858	116,998	136,790

Liquidation of the operator's equity = 0
Cash outstndings after the liquidation = 22,598

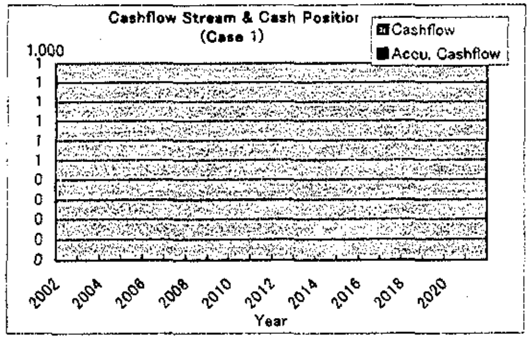
			2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
O	Profitability	5.0%	-27,000																				
		Profit at sale	0												27,000								
	Operator	ROE =	-27,000	0	0	0	0	0	0	0	0	0	0										
	(for 10 years)																						
	Equity owner		-40,500	11,466	11,856	12,259	-10,712	-1,776	9,308	10,003	-14,179	10,617	-16,244	16,582	-7,755	16,882	17,456	2,449	-6,767	17,902	18,511	19,141	19,791
	(for 20 years)	Accu. Cashflow		11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	79,347	97,858	116,998	136,790

	Balance Sheets	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
H, I	*Loan*	*27,000*	*27,000*	*27,000*	*27,000*	*27,000*	*27,000*	*21,600*	*16,200*	*10,800*	*5,400*	0	0	0	0	0	0	0	0	0	0	0
	User's contribution	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500	13,500
	Additional equity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Equity	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000	27,000
	Retained earnings	0	-3,204	-6,018	-8,429	-8,911	-9,758	-9,719	-8,986	-7,535	-6,188	-4,102	-2,191	285	2,497	5,282	8,662	12,124	15,357	19,198	23,668	28,790
	Subsidy	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500	67,500
	Liabilities & Equity	135,000	131,796	128,982	126,571	126,089	125,242	119,881	115,214	111,265	107,212	103,898	105,809	108,285	110,497	113,282	116,662	120,124	123,357	127,198	131,668	136,790
	Cash	0	11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	79,347	97,858	116,998	136,790
	Assets	135,000	120,330	105,660	90,990	101,220	102,150	87,480	72,810	83,040	68,370	81,300	66,630	76,860	62,190	47,520	48,450	58,680	44,010	29,340	14,670	0
	Assets	135,000	131,796	128,982	126,571	126,089	125,242	119,881	115,214	111,265	107,212	103,898	105,809	108,285	110,497	113,282	116,662	120,124	123,357	127,198	131,668	136,790

Chart 3.2 (4) Financial Business Model for PV Rural Electrification

Cashflow Stream & Cash Position (Case 1)																					
(In case of liquidation)		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
	Cashflow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Accu. Cashflow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Cashflow Stream & Cash Position (Case 2)		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
(In case of no liquidation)	Cashflow	11,466	11,856	12,259	-10,712	-1,776	9,308	10,003	-14,179	10,617	-16,244	16,582	-7,755	16,882	17,456	2,449	-6,767	17,902	18,511	19,141	19,791
	Accu. Cashflow	11,466	23,322	35,581	24,869	23,092	32,401	42,404	28,225	38,842	22,598	39,179	31,425	48,307	65,762	68,212	61,444	79,347	97,858	116,998	136,790



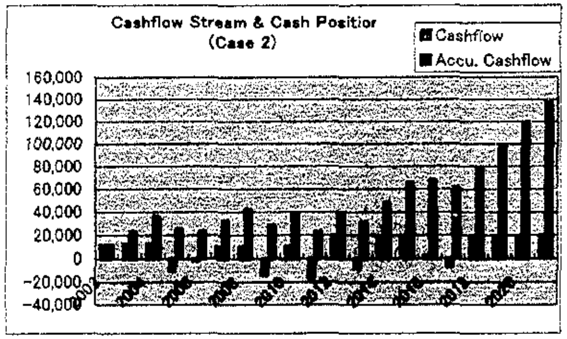


Chart 3.3 Financial Plan for PV Rural Electrification

Pre-conditions
Case III No. of total installation units : 70,000
Subsidy rate : 50%

1 English, 0 French

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
Installation Units	(55 Wp)	1,000	2,000	2,000	2,500	2,500	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	70,000
Price of PV System in US$	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	600	
Exchange rate US$=	750	788	827	868	912	957	1,005	1,055	1,108	1,163	1,222	1,222	1,222	1,222	1,222	1,222	
Price of PV system in CFA	450,000	472,500	496,125	520,931	546,978	574,327	603,043	633,195	664,855	698,098	733,003	733,003	733,003	733,003	733,003	733,003	
Subsidy	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	50%	
Annual reduction in subsidy %	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	
Loan	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	
(Subsidy + Loan) (%)		70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	70%	
Total Amount of Financial Support from ASER (A)	(Million CFA)	331	695	729	957	1,005	2,533	2,659	2,792	2,932	3,079	3,079	3,079	3,079	3,079	3,079	33,105
Total Amount of Technical Support from ASER (B)	(Million CFA)	66	139	146	191	201	507	532	558	586	616	616	616	616	616	616	6,621
(B)/(A) =	20%																
Total Amount	(Million CFA)	397	833	875	1,149	1,206	3,039	3,191	3,351	3,518	3,694	3,694	3,694	3,694	3,694	3,694	39,726
Exchange Rate US$ =	750	788	827	868	912	957	1,005	1,055	1,108	1,163	1,222	1,222	1,222	1,222	1,222	1,222	
Devaluation growth of CFA =	5.0%																
Total Amount	(Million US$)	0.50	1.01	1.01	1.26	1.26	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	3.02	35.3
Accumulated Amount	(Million US$)	0.5	1.5	2.5	3.8	5.0	8.1	11.1	14.1	17.1	20.2	23.2	26.2	29.2	32.3	35.3	

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	
Total Amount (Million CFA)	397	833	875	1,149	1,206	3,039	3,191	3,351	3,518	3,694	3,694	3,694	3,694	3,694	3,694	39,726
Total Amount (Thousand US$)	504	1,008	1,008	1,260	1,260	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	3,024	35,280
Installation Units	1,000	2,000	2,000	2,500	2,500	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	70,000
Accumulated Units	1,000	3,000	5,000	7,500	10,000	16,000	22,000	28,000	34,000	40,000	46,000	52,000	58,000	64,000	70,000	

Major assumptions:
Devaluation growth of CFA = 5.0% 0.0% 3.0% 5.0% (No change of exchange rate is applied for the years after 2010)

Case Study 5.0% 39,726 35,280

Devaluation growth of CFA	0%	3%	5%
Total Amount (Million CFA)	[illegible]	[illegible]	39,726
Total Amount (Thousand US$)	35,280	35,280	35,280